This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

LANE MEDICAL LIBRARY STANFORD
J53 .H69b 1889 STOR
Analysis of the urine : with special ref
24503412544

P. K Watters

LANE
MEDICAL LIBRARY

SEAL OF THE LELAND STANFORD JUNIOR UNIVERSITY
1885

P. K. Watters, M.D.

Library of

Dr. P. K. Watters

P. K. Walters.

P. K. Walters, M.D.

ANALYSIS OF THE URINE,

WITH SPECIAL REFERENCE TO THE

DISEASES OF THE GENITO-URINARY ORGANS.

BY

K. B. HOFMANN,
PROFESSOR IN THE UNIVERSITY OF GRATZ,
AND
R. ULTZMANN,
DOCENT IN THE UNIVERSITY OF VIENNA.

TRANSLATED AND EDITED BY
T. BARTON BRUNE, A. M., M. D.,
FORMERLY PROFESSOR OF THE PRACTICE OF MEDICINE IN THE BALTIMORE POLYCLINIC AND
POST-GRADUATE MEDICAL SCHOOL, AND LECTURER ON CLINICAL MEDICINE
IN THE UNIVERSITY OF MARYLAND,
AND
H. HOLBROOK CURTIS, PH. B., M. D.,
FELLOW OF THE NEW YORK ACADEMY OF MEDICINE, MEMBER OF THE COUNTY SOCIETY, ETC.

THIRD EDITION, REVISED AND ENLARGED.

NEW YORK:
D. APPLETON AND COMPANY,
1, 3, AND 5 BOND STREET.
1889.

LANE LIBRARY

Copyright, 1879, 1886, 1889,
By D. APPLETON AND COMPANY.

TRANSLATORS' PREFACE.

WE have undertaken the translation of this little work, hoping that it will supply a need which has been long felt by American students and physicians. We do not know of a single work in the English language where, in a concise form, so many valuable suggestions and practical hints are offered, both as regards analysis and diagnosis. The book does not pretend to be an elaborate and exhaustive treatise on the diseases of the genito-urinary organs; such an idea is at once precluded by the title and size of the work. It merely claims to contain all that is necessary for the student and practicing physician.

The merit of the work is sufficiently attested by the popularity it already enjoys in Germany and Austria, and the fact of its having appeared in three languages during the year of its publication.

83963

While making no claims to elegance of translation, we have endeavored to be faithful to the original text, and at the same time to explain the methods of procedure so clearly, that without other aids the student may be able to perfect himself in the rapid analysis of the urine, and furthermore to draw his conclusions from the same. The added plates, which do not appear in the German edition, are principally taken from "Ultzmann and Hofmann's Atlas der physiologischen und pathologischen Harnsedimente," and from photographs kindly furnished by Dr. Ultzmann, under whose supervision we have performed our work.

THE TRANSLATORS.

VIENNA, *December* 20, 1878.

AUTHORS' PREFACE.

Dr. T. Barton Brune, A. M., M. D., and Dr. H. Holbrook Curtis, Ph. B., M. D., the translators of our "Analysis of the Urine," have requested of us a preface for the Second English Edition.

We willingly comply with this request, and wish to express our gratification at the reception our book has met with in the United States. Our object in writing has been to provide practitioners in medicine with a clear and concise guide to the diagnosis of diseases, especially those affecting the urinary apparatus.

We have eliminated all unnecessary matter, and have endeavored to make our processes so simple that but a limited knowledge of chemistry will be necessary to understand our tests. Though we could not ourselves undertake to revise the new edition, on account of the distance and the limited time allowed for the introduction of new matter, we do not doubt that the high qualifications of the translators will be a warrant for the correctness of the work.

PROF. K. B. HOFMANN.
DR. R. ULTZMANN.

VIENNA, AUSTRIA, *February*, *1886*.

TRANSLATORS' PREFACE TO THE SECOND EDITION.

THE *raison d'être* of this edition is to be found in the recent advances made in urinary analysis, particularly during the last three years, and in the gratifying fact that, in spite of the simultaneous appearance of a translation made in the West and unauthorized by the authors, our own translation has been exhausted. We have endeavored to revise the previous edition, and to incorporate in this all that has recently been added to our knowledge which will be of especial interest to the student and practitioner of medicine. At the end of the work is appended a translation of Dr. Ultzmann's description of his saccharimeter. All additions made by us to the original text are inclosed in brackets [ ].

THE TRANSLATORS.

December 15, 1885.

TRANSLATORS' PREFACE TO THE THIRD EDITION.

It is a fact pleasing to the translators and editors of this work that a third edition should be called for in so short a time after the appearance of the second. And yet, short as the time has been, so much has been published during this period upon the investigation of the urine that it has been no easy task to incorporate in the present volume all the recently acquired knowledge which is of importance for physicians and students of medicine. Much has necessarily been omitted, but we do not believe that it has been to the detriment of that portion of the public for whom this work is intended.

In the form of appendices we have introduced a short sketch of albuminuria in its latest aspects, and have mentioned some of the newer and more promising tests for albumen and sugar. We have also given a brief account of some reducing substances which are of practical importance in view of their reactions with certain tests commonly used for the detection of sugar.

As before, our additions to the text are inclosed in brackets [ ].

THE TRANSLATORS.

TABLE OF CONTENTS.

PAGE
INTRODUCTION 13

CHAPTER I.

HISTOLOGY OF THE URINARY ORGANS 19
1. The Kidneys 19
   Urinary Tubules 21
   Blood-vessels of the Kidneys 24
   Nerves of the Kidney 26
2. The Excretory Ducts 26
   Ureters, Kidney-pelvis, and Calices 26
   Urinary Bladder 27
   Male Urethra 28
   Female Urethra 29

CHAPTER II.

THE EXCRETION OF THE URINE 30

CHAPTER III.

THE URINE 35
A. A General Description 35
B. Physical Characteristics 36
   1. Amount 36
   2. Specific Gravity 37
   3. Solid Ingredients 38
   4. Consistence 41
   5. Color 42
   6. Transparency and Fluorescence 45
   7. Odor 46
   8. Reaction 46
C. Chemical Composition 48
   a. Normal Organic Constituents 48
      1. Urea 49
      2. Uric Acid 56
      3. Coloring Matters 63

PAGE
- α. Urobiline 64
- β. Urine-Indican 66
- 4. Other Normal Organic Constituents 71
- b. Normal Inorganic Constituents 73
  - 1. Chlorides 73
  - 2. Phosphates 76
    - α. Earthy Phosphates 77
    - β. Alkali Phosphates 80
  - 3. Sulphates 82
- c. Abnormal Constituents 84
  - 1. Albumen 84
    - Nitric Acid Test 88
    - Boiling Test 89
      - [α.] Peptone 95
    - Potasseo-mercuric Iodide Test, for 99
    - Picric Acid Test, for 100
    - Sodium, Tungstate Test, for 102
    - Potassium Ferrocyanide Test, for 102
    - Metaphosphoric Acid Test, for 102
  - 2. Sugar 104
    - Heller's Test 105
    - Mulder's Test 107
    - Oliver's Test Papers 107
    - Trommer's Test 107
    - Robert's Test 109
    - Böttger's Test 110
    - Picric Acid Test 112
    - Vogel's Method of Approximative Determination . 118
    - Inosite 120
  - 3. Leucine and Tyrosine 124
  - 4. Abnormal Coloring Matters 125
    - α. Uroërythrine 125
    - β. Vegetable Coloring Matters 127
    - γ. Blood Coloring Matters 128
    - δ. Biliary Coloring Matters 131
  - 5. The Bile Acids 136
  - 6. Carbonate of Ammonium 140
  - 7. Sulphuretted Hydrogen 143
  - 8. Accidental Constituents 143
- D. The Sediment 146
  - Urine Fermentation 146
  - Classification of the Sediment 150
  - a. The Unorganized Sediment 151
    - 1. Urates 151
    - 2. Urate of Ammonium 153
    - 3. Uric Acid 154
    - 4. Calcium Oxalate 155

PAGE
5. Cystine 156
6. Leucine and Tyrosine 158
7. Fat 159
8. Earthy Phosphates 161
9. Magnesium Phosphates 164
10. Triple Phosphates. 164
11. Calcium Carbonate 165
b. The Organized Sediment 165
1. Mucus 165
2. Epithelium 167
3. Pus-corpuscles (Donné's Test) 169
4. Blood-corpuscles 171
5. Cylinders 173
6. Fungi 179
7. Spermatozoa 183
8. Cancer Elements 184
9. Entozoa 186

ADDENDA.

CONCRETIONS 189
Analysis of the Concretions 192

CHAPTER IV.

REAGENTS AND APPARATUS FOR THE APPROXIMATIVE DETERMINATION OF THE URINE CONSTITUENTS 197
Reagents 197
Apparatus 198

CHAPTER V.

QUANTITATIVE DETERMINATION OF A FEW OF THE CONSTITUENTS OF THE URINE 200
I. Estimation of the Degree of Acidity 201
II. Estimation of the Solid Matters 201
III. Estimation of Urea 202
1. Liebig's Method 202
2. Bunsen's Method 208
3. Knop-Hüfner's Method 209
IV. Determination of Uric Acid 210
V. Determination of Creatinine 212
VI. Determination of the Total Amount of Nitrogen . . . 213
VII. Determination of Albumen 215
VIII. Determination of Sugar 216
1. Fehling's Method 216
2. Knapp's Method 218

PAGE
IX. Determination of Chlorine 219
X. Determination of Phosphoric Acid 221
XI. Determination of Sulphuric Acid 223

CHAPTER VI.

KEY TO THE APPROXIMATIVE ANALYSIS OF THE URINE 224
Chemical Investigation 224
A. Nitric Acid 224
B. Heat Test 225
C. Test for the Normal Coloring Matters of the Urine . . . 227
D. Test for the Normal Inorganic Salts of the Urine . . 227
E. Further Tests for Abnormal Matters 227
F. Investigation of the Sediment 227

CHAPTER VII.

GENERAL DIAGNOSIS 232

CHAPTER VIII.

DIAGNOSIS OF THE DISEASES OF THE URINARY APPARATUS . . 241
A. True Albuminuria 242
1. Hyperæmia of the Kidney 242
2. Parenchymatous Nephritis 245
a. Acute Parenchymatous Nephritis 245
α. Catarrh of the Urinary Tubules, or Desquamative Nephritis 246
β. Acute Parenchymatous Nephritis proper . . 247
b. Chronic Parenchymatous Nephritis 249
3. Interstitial Nephritis 251
a. Hyperplastic Interstitial Nephritis—Cirrhosis of the Kidney—Genuine Kidney Atrophy 252
b. Suppurative Interstitial Nephritis. 253
4. Amyloid Kidney 255
B. Forms of Mixed Albuminuria 258
1. Pyelitis 258
a. Acute Pyelitis 259
b. Chronic Pyelitis. 261
c. Pyelitis Calculosa 262
d. Pyelitis Tuberculosa 265
2. Hæmaturia 268
3. Cysto-Pyelitis and Pyelo-Cystitis 279
C. Forms of False Albuminuria. 280
1. Cystitis—Bladder-Catarrh 281
2. New Growths in the Bladder 288
3. Bladder-Stone. 297
4. Diseases of the Urethra and Prostate 298
Description of Ultzmann's Saccharimeter 301
APPENDICES 306

ANALYSIS OF THE URINE.

INTRODUCTION.

The results of the generally complicated chemical processes upon which depends the basis of animal life are, on the one hand, the building up of the body, and on the other the breaking down of the same, both included in the common term "regressive (?) tissue metamorphosis." The used-up material—i. e., that which has lost its value to the animal economy—becomes eliminated by the skin and lungs (chiefly in gas form), and by the intestines and kidneys (in solid or liquid form).

In order to have a perfect conception at various times of the nutrition and state of the body (including the normal or pathologically changed material), the greatest possible care must be exercised in the investigation of the excretory ducts themselves, their precise function, and the nature of the material eliminated by them.

In order that the physician may obtain an adequate idea of the changes which take place in the organs of the body, it is important to observe carefully that most important secretion of the same, the urine.

The urine indicates, at least very nearly, by its qualitative and quantitative changes, the variation in tissue life. It offers in addition the advantage of easy collection, and its analysis, so far as it interests the practicing physician, can be made with simple apparatus. The kidney, inasmuch as it is subjected to disease, is not a lifeless filtering machine. Through its pathological processes material is added to the urine, from the presence of which alone is the physician able to make a diagnosis. The urine offers also in general an indication as to the condition of the entire body (including its constitutional diseases), and in particular concerning the secretory and excretory urinary apparatus. On account of the peculiarities of the numerous substances excreted by the kidneys, the urine possesses a great interest for the physiologist and chemist, and under certain circumstances for the medico-legal expert.

The endeavor to diagnose disease from observation of the urine extends back to the remotest period of medical research. The changes of the urine did not escape Hippocrates in his close investigation of diseases. He taught his scholars, under his personal supervision, the symptomatic and prognostical signification of changes in the urine, so far as the then existing state of the other sciences permitted. He directed attention to the external characteristics of the urine, its abnormal amount, color, and clearness, its cloudy or muddy appearance, and the visible differences of the sediment;

and he referred these indications to diseases of the urinary organs. However arbitrary his explanations of the appearances may be, his observations are for the most part correct. He even endeavored to demonstrate the influence of various foods and drinks on the constitution of the urine. We find also in the descriptions of diseases by Grecian writers the character of the urine considered according to his methods, without departing materially from the views of the great Coic physician. Since Galen more sharply defined and systematized the teachings of Hippocrates, they have prevailed as incontestable truths. For a long time after Hippocrates the investigations on the urine made no progress. Through the following century one finds but an occasional writer who added anything by his own investigations to these transmitted treasures.

To the Arabian Ibn Sina (980–1037), usually known as Avicenna, belongs the merit of having called attention to the fact that different external circumstances, as fasting, wakefulness, over-exertion, and strong emotions, have an influence upon the character of the urine. He proved also that absorbed medicines which are excreted by the kidneys would cause an accidental coloring of the urine. By his successors in the Arabian school nothing of importance was added, although, particularly in the East, each court had an examiner of urine (*uroscopen*). The most important writer on this subject in the ancient and middle ages is without doubt Johannes, surnamed Actuarius, who lived in the thirteenth century at the Byzantine Court. Uniting his experiences with the observations of the Hippocratic-Galenic schools, he treated in his seven-volumed work "περὶ οὔρων," in the minutest detail, the physiological and pathological changes of the urine. He gives even a description of the best methods of observation. In this he excels because of his clearly detailed demonstration. This work, in which nearly everything was exhausted which could be accomplished by the then existing methods, found in succeeding time so little emulation that this part of ætiology more and more declined. How far the interpretation of changes in the urine had advanced is most clearly demonstrated by the circumstance that it furnished material for the satirical representations of the Dutch school of genre painting, as well as for many comedies of Molière and other poets.

As they had most defective ideas as regards the chemical composition of urine, it was possible for the old observers to take into consideration only its physical properties. We can expect true progress only when chemistry and its methods of investigation have undergone marked development. This decided advance dates from the time of Lorenzo Bellini of Florence (1643–1704). Bellini evaporated the urine, and observed that by the gradual addition of water the residue was again dissolved, and the solution gradually brought back to its original condition, through different degrees of color and taste. He concluded thereupon that the variation of color and taste depended upon the ratio of the contained water to the solid constituents—a conclusion upon which even now Vogel's color scale is based.

Now important chemical discoveries followed quickly upon one another. Willis discovered sugar in the urine. Brandt discovered phosphorus, the origin of which Markgraff attributed to the contained phosphates. Rouelle the younger discovered urea in 1773, and found that in the urine of herbivora were contained carbonate of calcium and a substance, hippuric acid, related to flowers of benzole. In the year 1770 Cotugno found albumen in the urine; in 1798 Cruikshank declared the relation of this condition to dropsy; and in 1827 Bright proved the connection between kidney disease and albuminuria. At the same time attention was turned to the chemical analysis of gravel and calculi. Among the numerous deserving works on this subject are those of Scheele, Wollaston, Wetzlar, and Prout.

The present advanced state of uroscopy is due chiefly to the labors of two Frenchmen. Rayer's researches, which are included in his great work "Les maladies des reins" (1837–'41), laid the foundation of our present knowledge of kidney diseases. Becquerel, the son of the renowned physicist, had busied himself for a long time with urine analysis under Andral's direction, to whom he modestly assigns the credit of stimulating him to his investigations. He published the results of years of observation in his work "Sémiotique des urines" (1841). Through the thirty years which followed the publication of that book many observers turned their attention to this subject, so that no other part of organic chemistry possesses so full a literature as this.

After this short sketch of the development of our subject, it only remains to describe in a few words the arrangement of the matter which is here offered. After a cursory account of the microscopical construction and the function of the urinary apparatus, without a knowledge of which an understanding of its pathology is impossible, the physical properties and the chemical constituents of the urine will be separately treated, at least so far as is important for the practicing physician. A description of the microscopical part, viz., the sediment, will then be added. The many repetitions which occur are suitable rather than blameworthy for the beginner.

It is to be hoped that the short table for the method of investigation will not be useless to the beginner. The conclusion is formed of a compendium of the simple uncomplicated diseases of the urinary apparatus, as far as the indications form valuable signs for their diagnosis.

CHAPTER I.

HISTOLOGY OF THE URINARY ORGANS.

1. THE KIDNEYS.*

IF one cuts through the kidney from the papilla to the fibrous capsule, it is possible to clearly discern with the unaided eye a concentric arrangement of layers, i. e., the striated medulla and the more granular cortex surrounding the same.

If the blood and urinary vessels have previously been treated with different-colored injection fluids, it is possible to distinguish further subdivisions on the cut surface.

In the papillæ and close upon the same the kidney, by injection of the urine-tubes, shows striations; this portion is known as the papillary part of the medulla. Above this comes a section which is also striated; but the striations alternate with those filled with the colored injection fluid of the blood-vessels; this is known as the boundary or limiting layer of the medulla. The third and outermost layer surrounding the others is called the cortical layer.

---

* The investigations of Kölliker, Schweigger-Seidel, and Ludwig, serve as the basis for this description of histological relations.

By the colored injection fluids we distinguish the two component parts of the cortex. One of these is striated, and contains the injection fluid of the uriniferous tubes, which striations are the direct continuations of the straight tubes of the medulla, and are called medullary rays (Markstrahlen), or the prolongations of the pyramids; the other part shows principally small round bodies (glomeruli), colored by the injection of the blood-vessels, and is the so-called labyrinth of the kidney, or, in a narrower sense, the cortex.

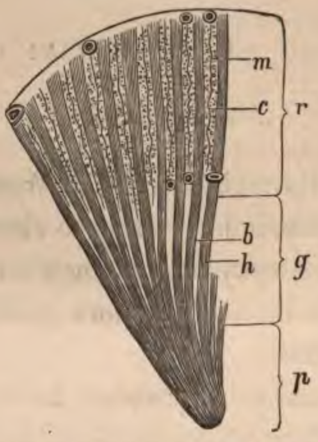


Fig. 1.—Plane section through the kidney of a dog: the urine- and blood-vessels injected. *p*, papillary part, and *g*, boundary or limiting layer of the medulla; *r*, cortex. The dark striations of the medulla, *h*, are bundles of urine-tubes. The continuations of the same into the cortex are the medullary rays, *m*. The light spaces of the medullary portion, *b*, correspond to the fasciculi of blood-vessels in the medulla. The light spaces of the cortex studded with dots (glomeruli), *c*, represent the situation of the labyrinth.

In support of this, with the microscope we find the papillary part to be made up of straight tubes; the boundary, partly of straight tubes and partly of straight blood-vessels; the medullary rays, principally of straight urine-tubes; and finally the labyrinth, partly of looped urine-tubules, and partly of tortuous blood-vessels.

This system of blood-vessels and urine-tubes is supported by a meagre stroma, denser in the medulla than in the cortex. On the external surface of the kidney this substance becomes a delicate membrane, which is loosely adherent to the fibrous capsule. The capsule is composed of ordinary connective tissue, with numerous fine elastic fibres. It envelops the whole organ, is inserted in the hilus, and, surrounding the blood-vessels, sends prolongations to the pelvis of the kidney.

The urinary tubules have their origin in the labyrinth. Each begins there with a spherical dilatation (capsula Malpighii), and "continues as a narrow neck, opening to a wider tube, which, after many windings, runs toward the medulla. When, as a wide, convoluted tube, it has reached the boundary, it suddenly becomes of less calibre, and as a narrow canal penetrates more or less deeply into the medulla; here the descending straight tube turns on itself, forming a narrow loop (Henle's loop), and runs directly upward toward and into the cortex. On reaching the cortex the canal does not seek the place of its origin, but avoids it and runs alongside the nearest medullary ray. Sooner or later it loses its straight direction, and with several convolutions passes as a widened tube (tubulus contortus) among the curved canals of the labyrinth. From there it turns and enters one of the tubes of a medullary ray (Bellini's tubes), the convexity of its curve directed toward the surface of the kidney, thus losing its independent course. The latter occurs as follows: Several canals run from different directions to the same place and become blended

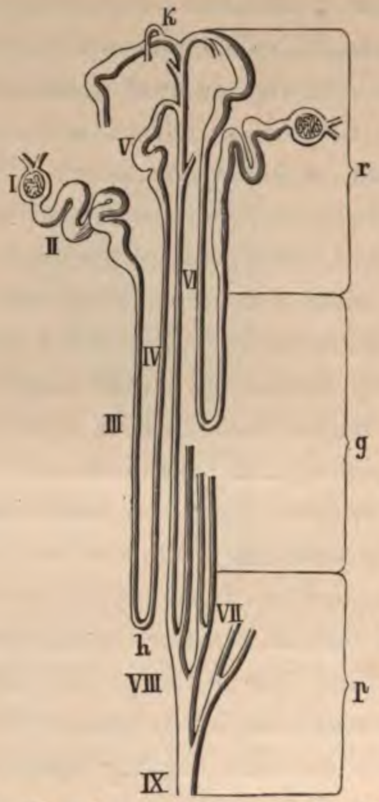


FIG. 2.—p, Papilla. g, Boundary. r, Cortex. I, Capsula glomeruli. II, Convoluted portion of tubule passing into III, descending branch of Henle's loop. h, Henle's loop. IV, Ascending branch of Henle's loop. V, Convoluted portion of tubule joining VI, tubulus Bellinianus. VII, Another tubulus Bellinianus. VIII, Common duct. IX, Ductus papillaris.

into a straight wide tube" (tubulus Bellinianus, Fig. 2): this runs a direct course until it reaches the papillary part of the medulla, where it unites with a neighboring

---

* The quotations are from C. Ludwig. See Stricker's "Handbook of Histology."

tube and so continues (Fig. 2, VIII.) until the united tubes, as the so-called ductus papillaris, empty into one of the calices.

The wall of the capsula Malpighii is made up of a mosaic of cells. The glomerulus is not directly surrounded by the fluid contents of the capsule, this being prevented by a layer of nucleated cells not easily defined, which covers the bunch of blood-vessels. "Beginning at the neck of the capsule, and extending as far as the commencement of the ductus papillaris, the canal wall consists of a tunica propria, lined on the inner surface with epithelial cells." The tunica propria is a homogeneous, vitreous, and elastic membrane.

The epithelium which lines the basement membrane is a single layer of nucleated cells. The form of the nuclei is always the same, round, sharply defined, and showing numerous granules. The body of the cell, on the contrary, varies much as regards form.

In the convoluted tubes the epithelium forms a continuous, jelly-like, opaque mass, with imbedded nuclei. A division of this mass into cells corresponding to the number of nuclei seems impossible. "This epithelial pulp lies only lightly upon the basement membrane; so that by making cross-sections of the tube the mass can be readily drawn out in a cylindrical form. Microscopically, fat-globules and other dark granules can be seen in this pulp, which is cleared up by addition of dilute acid. Often after the clearing up by acids isolated nuclei appear. In the small canals which form the arms of Henle's loops appears a thin and transparent lining epithelium, the cells of which by their nuclei are brought into clear relief."

On the other side of Henle's loops, where the diameter of the tubes becomes greater, the epithelium presents the appearance of true cylindrical cells, which are laid over one another as shingles, in a direction from the medulla to the cortex. In the tubuli contorti we find again the same jelly-like arrangement as in the curved tubes leaving the capsulæ Malpighii. In the straight tubes, even to the ductus papillaris, the epithelium is built up of a single layer of sharply defined cylindrical cells, with their broad bases toward the canal wall and their blunt points toward the lumen. (Pl. I., Fig. A, 1.)

THE BLOOD-VESSELS OF THE KIDNEYS.—The *arteria renalis* sends the greater part of the blood through the cortex. Its branches penetrate without forming meshes to the limit of the cortex, and here breaks up suddenly into very fine arteries, the arteriolæ interlobulares and arteriolæ rectæ.

The arteriolæ interlobulares run between every two medullary rays. Having reached the layer of convoluted tubules, they give off a small branch to each capsula Malpighii. This little branch (*vas afferens glomeruli*) pierces through the ball-like termination of the urinary canal (according to others, it only presses in), and breaks up here "into a free waving bunch of capillaries (glomeruli), which unite again within the capsule to form a common venous stem, the vas efferens glomeruli." This stem leaves the capsule in the same place that the vas afferens enters. After the vas efferens leaves the capsule, "it takes its direction toward its own medullary ray, or when this is wanting (as in the outermost layer of the cortex), at once toward the convoluted tubes, where it breaks up into a number of capillaries, forming a network of anastomosing meshes around the tubules." The vasa efferentia communicate by means of capillaries with one another throughout the cortex, and also with the vessels of the medulla, in the same manner.

The arteriolæ rectæ, which go from the cortex into the medulla, have their course in the slit-like spaces which lie in the limits of the medulla between the bundles of urinary tubules, and run to the papillæ, in the mean time dividing up into several parallel branches. When these vessels meet the converging bundles of the urinary canals, they break up into capillaries surrounding the urinary tubes, and then are distributed to the surfaces of the papillæ. This network of capillaries communicates with that of the cortex.

From the above-described capillary nets the venous stems arise. In the cortex of the kidney, especially in that layer external to the glomeruli, the union of venous stems is star-shaped (venæ stellatæ). The common venous stem penetrates that part of the cortex endowed with glomeruli and medullary rays, lies alongside of an arteria interlobularis, and receives numerous branches from the cortical network.

The venulæ rectæ run in the same clefts with the arteries, and on the border of the medulla unite with the veins coming from the cortex to form greater stems. The capsule receives its vessels partly from the arteriæ interlobulares, and partly from other arterial stems in the neighborhood, viz., the arteria phrenica, lumbalis, and supra-renalis. Their capillaries run partly into the venæ stellatæ of the cortex and partly into the veins corresponding to the above-mentioned arteries.

THE NERVES of the kidney are supplied by the plexus cœliacus of the sympathetic. Their terminations in the kidney are unknown. They run alongside the great blood-vessels in the same manner as the lymph-vessels which empty into the glands of the groin.

2. THE EXCRETORY DUCTS.

The *ureters, pelvis*, and *calices* have an external fibrous coat, a layer of unstriped muscular fibre, and an internal mucous membrane. The fibrous coat is continued into the tunica albuginea of the kidney, and is composed of ordinary connective and elastic tissue. The muscular coat of the ureters consists of three layers. The innermost is composed of longitudinal fibres, the middle of transverse, while the external and weakest is again made up of longitudinal fibres. In the pelvis the arrangement is the same. In the calices the muscular layers become thinner, and are finally wanting at the borders of the papillæ. The mucous membrane is thin, tolerably vascular, and without glands and papillæ. The epithelium is in layers, and is characterized by the size and form of its elements. The cells in the deep layer are round and small; in the middle layer they are cylindrical and spherical, and possess prolongations; while in the outer layer they are many-angled and flattened, and vary considerably as regards size. (Pl. I., A, 2.)

The Bladder possesses the same arrangement of layers. The muscular layer is often considerable, but the fibres run so irregularly that a schematic representation is impossible. The internal layer is found to be made up of a network of circular fibres, which form oblique and cross meshes about the neck of the bladder, and are in greatest quantity around its mouth, forming the sphincter vesicæ. Upon these circular fibres lie the more external muscular fibres, which run in different directions. The trigonum Lieutaudi consists simply of a thickening of the layers of connective tissue extending from the ureters to the caput gallinaginis. The mucous membrane has (except at the trigonum) a dense submucous layer, which is tolerably rich in blood-vessels and nerves, especially at the fundus and neck. In the neck and toward the fundus of the bladder are found glands formed like bunches of grapes, which have a cylindrical epithelium and mucous contents.

The epithelium of the bladder is of several coats, and varies like that of the ureters in its different layers. The innermost, which lines the cavity of the bladder, is composed of cells which show a more flattened appearance, but differ greatly in size and shape. The middle layer is formed of young cells with conical ends turned away from the cavity of the bladder. These prolonged ends often extend into the deep layer. The deep layer is composed of irregular oval cells, which, as opposed to the middle layer, have their smaller ends in the direction of the cavity of the bladder. (Pl. I., A, 3.) The blood-vessels of the bladder are the arteria vesicalis, superior and inferior, springing from the arteria hypogastrica. These enter the bladder wall at the fundus, piercing the muscular layer in an oblique direction. Here they give off branches, which break up into capillaries in the layer of connective tissue beneath the epithelium. The nerves are found in greatest abundance at the fundus, in the connective tissue of which it is possible to recognize the axis cylinders of their fibres. Their terminations are unknown. The blood-vessels and nerves of the ureters are similar to those of the bladder.

The Male Urethra has a corpus cavernosum with a fibrous coat and loose tissue similar to that of the penis, only much more delicate. It has a glandular organ, the prostate, which supports it. The mucous membrane permits to be seen beneath it a layer of connective tissue, rich in elastic fibres. External to this are transverse and longitudinal smooth muscular fibres, both in the pars prostatica and membranous portion of the urethra.

The epithelium of the male urethra is composed of cylindrical cells (Pl. I., B, 1), but in the forward half of the fossa navicularis we find papillæ and pavement epithelium. The epithelium of the ducts of the accessory glands, as the prostate, Cowper's, and Littré's, and that of the vesicula prostatica, is cylindrical and almost indistinguishable from that of the urethra (Pl. I., A, 4 and 5, and B, 3).

The Female Urethra has no bulb; the mucous layer is very vascular, and is lined with pavement epithelium (Pl. I., B, 2 and 3). Only a small number of Littré's glands are found.

CHAPTER II.

THE EXCRETION OF THE URINE.

THE function of the kidneys consists in the secretion of the urine; that of the bladder and urinary ducts, in the gradual collection, retention, and discharge of the same. A perfectly satisfactory explanation of the secretion and excretion of the urine in all its details is wanting.

Bowman advances the theory (in which he is supported by the anatomical construction of the kidneys) that the epithelial cells are the secretory organs, and that from the glomeruli only water escapes, which extracts the other constituents of the urine from the epithelial cells.

Ludwig bases his theory upon the varying blood-pressure in the renal vessels, and the interchange of constituents by osmosis through the animal membranes. He assumes that the pressure in the glomeruli is greater than in the capillary system immediately surrounding, and that consequently a profuse exudation of water occurs from the Malpighian tufts, which contains dissolved salts (also blood serum, a little albumen, and fat-globules). Accordingly, one finds in the urinary canals thin urine and in the surrounding capillaries thickened blood. These two fluids of such different densities, separated by a thin membrane, cause a ready osmosis, by means of which water from the urinary tubes enters the thickened blood; on the other hand, the urinary tubes receive from the blood the products of retrograde metamorphosis (urea and salts). In this manner the watery urine becomes more concentrated and richer in urea and salts—a true urine. The absence of albumen may be accounted for from the fact that it passes through animal membrane with much difficulty and only under great pressure. Under a pathologically heightened blood-pressure in the glomeruli (as stagnation of the renal venous system), one always finds albumen in the urine, but never under a physiological blood-pressure. Though this theory explains many physiological and pathological facts, it does not show how an acid urine can be secreted from an alkaline blood-serum. Hence the mechanical theory of Ludwig attributes to the glomerulus a process of filtration, and in the further course of the urinary tubes a process of osmosis, the office of the epithelium being wholly left out of consideration.

According to Goll and Max Hermann, the difference in pressure between the contents of the blood-vessels and the urinary tubules constitutes a chief motive power which forces the urinary constituents of the blood into the urinary tubules. Consequently if the blood-pressure in the renal artery is increased, then there is an increase in the amount of urine secreted; but if the blood-pressure in the renal artery is diminished, or the pressure in the ureter approaches the normal blood-pressure in the artery, then is the secretion of urine lessened or made to cease entirely, long before the pressure in the ureter has reached the amount of pressure in the renal artery.

Ustimowitsch and Grützner have elaborated these theories to such an extent as to demonstrate, by experiments on the dog, that the secretion of urine is not dependent upon the general blood-pressure, but upon the local pressure in the glomeruli of the kidney. If the medulla oblongata of a dog be divided and the general blood-pressure be artificially increased by a current of electricity, the secretion of urine is prevented entirely, for the reason that the small vessels of the kidney become contracted. If now the nerves of one kidney be divided, there ensues a profuse secretion of urine on that side, while no urine flows through the ureter of the other kidney. This is due to the fact that by section of the vaso-motor nerves of the kidneys the smallest arteries become expanded and relaxed, by which means the blood-pressure in these small vessels is increased and the secretion of urine brought about. Ustimowitsch also shows that by a diminution of the general blood-pressure an increase in the secretion of urine ensues. If one, for example, cuts through the sympathetic nerve, which contains the vaso-motor branches for the kidney, the blood-pressure in the aorta is reduced, but at the same time an expansion of the small renal arteries occurs, causing an increase of the urinary secretion.

Heidenhain and Wittich support the theory of Bowman in regard to the secretory function of the epithelium; while they prove, by their experiments with indigo-sulphate of sodium, urate of sodium, and carminate of ammonium, that these substances become separated by the epithelial cells.

K. Müller's investigations show that the excretion of urine is increased by the application of cold to the skin, as fomentations or dressings; but by the application of heat, as in a warm bath, or by varnishing the skin, the excretion is diminished, the blood-vessels of the skin being dilated. A diminution of the quantity of blood in the skin capillaries increases the urinary secretion, while an increase of the former diminishes the latter.

According to Wendt, the increase of intra-abdominal pressure hinders the excretory process, probably by an increase of pressure in the renal veins, by which circumstance, as we know (Ludwig), the secretion of urine is checked.

Maly, Donath, and Posch have proved that, by the agency of osmosis, an acid fluid may be obtained from a watery solution of several salts (as mono- and di-sodic phosphates), which together give a neutral or slightly alkaline reaction with litmus. This is a discovery of importance, as it obviates the necessity of attributing to the renal epithelium the chemical property of acid formation.

Notwithstanding all these theories, there is no hypothesis which gives a perfectly satisfactory explanation of all the physiological and chemical processes of urinary secretion. We must therefore look upon the excretion of urine as a compound process of secretion and filtration.

[The theory of secretion, pure and simple, has perhaps gained ground recently owing to the advocacy of Heidenhain * and his followers. He accepts the facts, abundantly proved by Nussbaum and others, that the specific constituents of the urine, such as urea, are secreted by the epithelium of the urinary tubules, and that the water and salts come from the glomeruli, not by mere filtration, but by specific action of the cells covering the glomerular tufts. These cells, moreover, when in normal condition, prevent the passage of albumen, and only allow it to escape in case of lesion or deficient nutrition. Senator,† in our opinion, has, however, ably controverted this view as applied to the glomeruli, and the separation of urine is to be considered now, as when the first edition of this work was presented, as a combination of both filtration and secretion.]

[* Hermann's "Handbuch der Physiologie," Bd. V., Part i.

† "Albuminuria in Health and Disease," and Appendix (1), by Dr. H. Senator. "New Sydenham Society Publications," 1884.]

CHAPTER III.

THE URINE.

A. A GENERAL DESCRIPTION.

THE urine is the secretion of the kidneys, and under normal conditions is essentially a solution of such ingredients as belong to retrograde tissue-metamorphosis. It is a solution of urea and chloride of sodium, to which are added in less proportion other organic and inorganic constituents of the blood, as well as certain foreign matters introduced into the organism, which are excreted through the kidneys unaltered or having previously undergone chemical transformation.

In a normal condition the urine contains in part organic constituents, as urea, uric acid, creatinine, hippuric acid, xanthine, lactic acid, coloring matters, indican, grape sugar (Brücke), [albumen (Senator)], etc.; partly inorganic, as chloride of sodium, phosphates of sodium, magnesium, and calcium, sulphates of the alkalies, ammonium salts, iron (as a constituent of the coloring matters), and gases—carbonic acid, nitrogen, and oxygen. In pathological urine, besides the normal constituents, are found also albumen, grape sugar, inosite, biliary matters, fat, sulphuretted hydrogen, coloring matters of the blood, uroërythrine (Heller), leucine, and tyrosine, oxalate and carbonate of calcium, carbonate of ammonium, cystine, pus, blood, epithelium, spermatozoa, fungi, and infusoria.

Before we take into consideration the semeiotic significance of the urine, we will describe its peculiarities as far as important to our subject, and the most useful methods of investigation.

B. PHYSICAL CHARACTERISTICS.

1. *Amount.*

The amount of urine excreted by a healthy person, who eats and drinks moderately, varies between 1,400 and 1,600 c.c., the mean average for the twenty-four hours being 1,500 c.c.

One passes most in the afternoon, less in the morning, and the least at night; for, under ordinary conditions, in regard to its quantity, the morning urine is least influenced by meals and other circumstances, and approaches a mean between the excretions of afternoon and night. The urine increases in proportion to the amount of imbibed fluids (*urina potus*). Its amount is increased also, though much less perceptibly, by cold and atmospheric moisture, whereby the perspiration is lessened. During rest, or by such circumstances as profuse perspiration or profuse diarrhœa, the urine diminishes.

2. *Specific Gravity.*

The specific gravity of normal urine (1,500 c.c.) is between 1·015 and 1·021. When the amount of urine is lessened, the specific gravity is correspondingly increased, standing in inverse ratio. Pathologically the urine varies between 1·003 and 1·040. Especially important are those cases in which we find with a lessened volume a lower, and with a greater volume a higher, specific gravity. We often find a higher specific gravity in mellituria, in the beginning of acute febrile diseases, and after the administration of neutral salts. An increased amount and a specific gravity between 1·030 and 1·040 is suggestive of mellituria. A lower specific gravity is to be observed in hydruria, urina spastica, and urina potus.

The specific gravity is best obtained by means of a pyknometer, or by scales; though for practical purposes less complicated means of investigation answer. For immediate determination the urinometer is very convenient.

The surest method of ascertaining the exact specific gravity by the urinometer is as follows: One fills a small standing glass cylinder tube four fifths full of the urine; the froth being removed by filter paper, the urinometer is allowed to sink into the urine guided by the supported right hand, never being allowed to come into contact with the side of the tube. Bring the eye on a level with the surface of the urine, and read the division corresponding with this surface (not the upper rim of the fluid raised slightly on the stem by attraction). Touch the stem, causing the urinometer to sink slightly in the fluid; and, when it comes to rest, read again.

In all urinometrical observations, the urine should have a temperature between 12° and 17° C.; otherwise considerable errors may be made.

If the amount of urine is small, dilute with even three or four volumes of water: test as directed above, and multiply the number read off by the number of volumes made by the dilution. For example: If three volumes of water be added to one volume of urine, and we read 1·008, to obtain the real specific gravity of the original fluid 1·008 is multiplied by $1 + 3 = 4$ $(1·008 \times 4 = 1·032)$. The solid materials (on which the specific gravity depends) which formerly were dissolved in one volume are after the dilution dissolved in four volumes: the specific gravity is therefore only one fourth of the specific gravity of the original; or, what is the same thing, the specific gravity of the original is four times the specific gravity of the dilution.

3. *Solid Ingredients.*

In normal urine the solid materials excreted in twenty-four hours are generally 60 to 70 grammes. Should we find say 200 grms., diabetes is indicated. If, on the contrary, we find a very small amount of solids excreted, say 20 grms., and the quantity of urine not correspondingly diminished, it indicates hydruria. In order to estimate the amount of solid constituents excreted in twenty-four hours, one can employ either the coefficient of Trapp (2), or that of Häser (2·33). (For the exact determination, see Chapter V.) By multiplying the decimal of the specific gravity by the coefficient, we have as the result (in grammes) the weight of solids contained in 1,000 c.c. of urine. Hence, if we have the entire amount passed in twenty-four hours, we can easily estimate the weight of solids contained in the whole. For example, we have 1,500 c.c passed in twenty-four hours, of sp. gr. 1·020; to estimate the weight of solids in 1,000 c.c., we multiply the decimal 20 (the last two figures) by the coefficient of Häser, 2·33 ($20 \times 2{\cdot}33 = 46{\cdot}60$), and the product, 46·60, is the weight in grammes of the solids in 1,000 c.c. of the urine.

Now by the proportion, $1{,}000 : 1{,}500 :: 46{\cdot}60 : x$, we are able to estimate the amount of solid materials contained in the excretions of the twenty-four hours. In the given example x would represent the unknown solids, and $x = 69{\cdot}90$, the weight in grammes of the solid materials contained in the twenty-four hours' secretion of normal urine.

In the following examples will be considered the amount of solids excreted in different urines in the course of twenty-four hours:

Example 1.—Amount of urine, 4,000 c.c.; sp. gr., 1·007.

$$7 \times 2{\cdot}33 = 16{\cdot}31.$$

1,000 c.c. of this urine contain 16·31 grms. of solids, and 4,000 c.c. contain 65·24. We see in this example that the quantity of solids is normal, but simply the amount of fluid has increased. This may be an indication of *polyuria*, or may be entirely physiological, as urina potus.

Example 2.—Amount of urine, 6,000 c.c.; sp. gr., 1·013.

$$13 \times 2{\cdot}33 = 30{\cdot}29, \text{ solids contained in } 1{,}000 \text{ c.c.}$$
$$\text{and as } 1{,}000 : 6{,}000 :: 30{\cdot}29 : x,$$
$$x = 181{\cdot}74 \text{ grms.}$$

In this example we find the amount of solids excreted in twenty-four hours to be more than double the normal quantity. This urine would consequently suggest diabetes.

Example 3.—Amount, 2,000 c.c; sp. gr., 1·005.

$$5 \times 233 = 11{\cdot}65$$
$$1{,}000 : 2{,}000 :: 11{\cdot}65 : x.$$

2,000 c.c. contain 23·30 grms. of solid materials. The solids are deficient here in the twenty-four hours' excretion, and hydruria is indicated.

The differential diagnosis between diabetes insipidus and hydruria on the one hand and urina potus on the other, as well as between oliguria and normal urine, can be made by an estimation of the solid constituents.

Besides these, other valuable conclusions may be drawn from the amount of solids and the specific gravity; but each case has a special significance. For example, if we have a diseased kidney, the amount of urine normal or diminished, and with a very low specific gravity, then we can determine, since urea composes nearly half the solid constituents, that there has not been a sufficient quantity of the same excreted; consequently we may expect uræmia, and very soon.

As the proportion of the solid constituents to one another does not remain constant, therefore we can not estimate accurately any single one from the specific gravity. The variation in the amount of solids may be 6 per cent. (in urine with abnormal constituents, even more). For example, if we found yesterday 1,000 parts of urine to contain 50 grms. of solids, and to-day 47 or 53, we can not speak positively of an increase or decrease.

In judging of the variations of the solid matters from the specific gravity, we must further take into consideration whether the patient has received his customary amount of food, or (as is the case in all febrile processes) has fasted. In the latter case we must regard 30 grms. as the average. If a person having pneumonia, placed upon a strict diet, excretes 40 grms. of solid matters, we must consider it an increase, and that accomplished at the expense of the feverish body.

4. *Consistence.*

The consistence of normal urine is that of a thin, easily dropping fluid. Pathologically it becomes viscid, as when there is a great amount of pus in a strongly alkaline urine. The urine becomes stringy, similar to the contents of a par-albuminous cyst. If we dilute with water and add a drop of acetic acid, a copious turbidity ensues, indicating the presence of an alkaline albuminate, formed by the action of a strongly alkaline urine on the pus.

Upon the Isle of France, a urine is often observed which soon after passage into the vessel coagulates as lymph and contains fibrine (fibrinuria). In our latitudes such urine occurs but seldom, and the condition lasts but a moment. We have observed temporary fibrinuria in cases of villous tumor of the bladder. In these cases the fluid, of a yellowish-red color and containing a slight quantity of blood, thickened after a few moments to a quivering, jelly-like mass, which could not be poured from the receptacle.

If we shake normal urine, a foam appears which vanishes soon on standing. If the urine contains sugar or albumen, the foam remains for a considerable time.

5. *Color.*

The color of a normal urine whose specific gravity is 1·020 and amount in twenty-four hours 1,500 c.c. is wine-yellow. By concentration, it becomes dark wine-yellow, then amber-yellow; by dilution it passes through pale wine-yellow to straw-yellow. Morning urine from freely perspiring persons has always a darker, and from urina potus a lighter, color. The color of the urine, besides the physiological changes, is subjected to greater variations in disease; in the latter case the appearance is frequently affected by abnormal coloring matters.

The urines may be classified according to their departure from the normal standard of color.

1. *Almost colorless urine.*—Especially in neuroses, there is sometimes a "urina spastica" produced, and the urine can scarcely be distinguished from water. By other causes, such as hydruria, as well as diabetes, the urine is rendered almost colorless, though the yellow color is still recognizable. By standing a few hours a light may become a darker urine. Pale urine occurs when, with a normal amount of coloring matters, the water is increased (as in urina potus, urina spastica), or when with a normal amount of water the coloring matters are in less quantity (as in granular kidneys); but in most cases an increase of water and lack of coloring matters concur in making the urine pale.

2. *Highly colored urine.*—These urines are dark yellow with a tendency to red, even to flame-red. This is not simply due to a concentration of the urine, but often depends upon the presence of uroërythrine. This is brought about by acute febrile processes in a stage of increase or climax.

3. *Blood-red or garnet-red urine* is always caused by foreign coloring matters. A number of vegetable matters excreted through the kidneys impart to alkaline urine a red color. A similar appearance is caused by the passage of blood into the urine (for proof of which see chapter on abnormal coloring matters).

4. *Dark brown to nearly black urine* is induced by methæmoglobine from diseases of the kidney, especially hæmorrhage; also by the passage of biliary coloring matters into the urine (icteric urine), and by the passage of coloring matters as yet comparatively unknown; for example, when colored by long-continued intermittent fever.

Sometimes, after long standing, urine of melanotic cancer becomes almost black; but, as the coloring matter of melanotic cancer has been found in the urine without the existence of the cancer, and, *vice versa*, melanotic cancer being present and the color wanting in the urine, we are not able to use this as a means of positive diagnosis. After the external use of carbolic acid (for example, Lister's dressing), we are apt to find very dark urine, though this appearance is not always constant. In children the urine is often seen to be colored, after some time, from the surface toward the bottom.* In leprosy the fact is observed that toward death the characteristic dark-red urine becomes dark brown (urorubrohæmatine).

5. *Green urine* of a dirty hue comes from jaundice, and is caused by the presence of biliverdine, having the same significance as brown icteric urine. (For a consideration of biliary coloring matters, see chapter on abnormal coloring matters.)

6. *Dirty-blue urine.*—This shows generally a dark-blue film and a similar sediment from indigo. This has always an alkaline reaction, and exists chiefly in connection with cholera and typhus.

[* This has been seen recently in cases of adults, and proved to have been caused by pyrocatechuic or protocatechuic acid. The urine in these cases was colored red from the surface downward.]

6. *Transparency and Fluorescence.*

Normal urine is always clear and transparent, and shows after standing some time a mucus-cloud. Microscopically we find isolated pavement epithelium and young cells. The urine of women shows usually a denser mucus-cloud (nubecula) and more epithelium (generally overlapping), which comes from the vagina. Pathological urine may become clouded from any of those substances which after long standing form a sediment.

If we desire to prove by chemical means the origin of this cloudiness, we proceed as follows: A test tube is a third filled with the urine to be examined, and is carefully heated over a Bunsen burner or spirit lamp.

(*a.*) If the cloudiness disappears, salts of uric acid (urates) are indicated, which were suspended in the urine on excretion.

(*b.*) If the cloudiness increases, on the other hand, calcium carbonate, suspended earthy phosphates, or the albuminous cell elements (pus, blood) are indicated.

To distinguish between the above, we add a few drops of acetic acid. If the urine clears up, the earthy phosphates composed the cloudy precipitate. If, on the contrary, it becomes more cloudy, this in most cases is due to suspended pus or blood.

(*c.*) If it remains unchanged, or we notice after the addition of acetic acid a slight increase of the cloudiness, mucus and bacteria are present in unusual quantity.

Normal urine shows at times a peculiar white fluorescence, the cause of which is not exactly understood. Alkaline urine shows by reflected light a greenish, by transmitted light a yellowish-red, color. Some urines show the spectrum of urobiline.

7. *Odor.*

The odor of fresh normal urine is slightly aromatic. The cause of this is at present unknown. If the urine has become alkaline by standing, we perceive an ammoniacal odor. From destructive processes in the bladder we observe frequently a peculiarly repulsive, foul, and even fæcal smell. By the use of certain foods and medicines, the odor of the urine is strikingly altered. For example, asparagus, cauliflower, etc., impart a repulsive smell. Turpentine administered internally induces the perfume of violets. The odorous principles of cubebs, saffron, and some other substances pass into the urine.

8. *Reaction.*

Normal urine possesses an acid reaction, which is due especially to the acid alkali-phosphates. The acid reaction may be also due to the presence of a free organic acid (lactic?); but the part this acid plays is a subordinate one. If we add to a fluid containing free acid a solution of hyposulphite of sodium, it causes a turbidity which occurs instantly or in a few minutes (by the separation of sulphur), according to the amount of free acid present. If we apply this test to urine, after twenty-four hours there is but a slight precipitate, if any. There can consequently be only a small amount of free acid in the urine, although this proof is rather unsatisfactory.

Sometimes, directly after a meal, an alkaline urine is passed; but after a few hours this phenomenon disappears, and it is without clinical significance.

A strongly acid reaction of the urine is important to the physician, inasmuch as it gives rise to the origin of certain sediments or concretions which irritate the kidneys and urinary passages (Vogel). 349

By standing, an acid urine becomes neutral or alkaline. By administration of the alkaline or earthy carbonates, or the salts of the vegetable acids (acetic, malic, tartaric, etc.), which in the organism become carbonates, an alkaline reaction is imparted to the urine; just as the ammonium carbonate, which is formed from urea by the taking up of the elements of water, renders the urine alkaline after standing. At first the ammonium carbonate just suffices to neutralize the urine; consequently the neutral reaction has the same signification as the alkaline.

A strongly alkaline urine may almost always lead us to conclude that an affection of the bladder exists—if we exclude the formation of the carbonates by decomposition.

The reaction of the urine is usually tested with delicate blue and red litmus paper. We must observe whether the urine is alkaline when it is excreted from the bladder, or has become so after its passage, and in what length of time it has become alkaline; and further, whether the alkalinity is due to the ammonium carbonates (from the breaking up of urea) or the fixed carbonates (taken into the body as nourishment or medicines). We may determine to which the alkalinity is due; for in the first case, on exposure for some time to warm air, the red color of the litmus paper will return; but, if the reaction is from fixed alkalies, the test paper remains blue after drying.

Sometimes we observe urine which colors blue litmus paper slightly red, and the red paper slightly blue. This reaction is known as amphoteric. It has no satisfactory explanation, and is without symptomatic value.

C. CHEMICAL COMPOSITION.

a. Normal Organic Constituents.

In referring to the constituents of the urine, so called, the following table expresses the average quantity of each excreted in twenty-four hours:

CONSTITUENTS.	GRAMMES.	PER CENT.
Total solids	60 —70	4·3 —4·6
Urea	30 —40	2·5 —3·2
Uric acid	0·4— 0·8	0 03 —0·05
Creatinine	0·5— 1·0	0·036—0·062
Hippuric acid	0·3— 1·0	0·02 —0·06
Chlorides	10 —13	0·7 —0·8
Earthy phosphates	0·9— 1·3	0·07 —0·08
Phosphoric acid	2·5— 3·5	0·19 —0·22
Sulphuric acid	1·5— 2·5	0·16 —0·17

We see from this that urea and the chlorides are the principal constituents. It is apparent that, if one of these matters is wanting or is excreted in diminished quantity, it will influence greatly the specific gravity. This does not hold true to the same extent with the other constituents, which are relatively excreted in very small quantity.

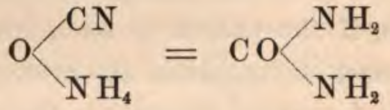
The dissolved gases are of little importance. Carbonic acid gas exists in greatest quantity—60 to 150 c.c. in 1,000 c.c. of urine. Nitrogen is next in amount, and there are only traces of oxygen.

1. *Urea.*

Urea, $CO\,N_2\,H_4$, is the most constant of all the constituents of the urine, and exists in greatest quantity, 30 to 40 grms. being secreted in twenty-four hours by a healthy adult. On a flesh diet more is excreted, less upon a mixed, and least of all upon a strictly vegetable diet. From inanition the secretion may fall to 20 and even to 15 grms. In calculating the extent of tissue-metamorphosis, if the patient is on a low diet these latter figures must be considered the average.

The simplest way of separating the urea from a urine is to throw down the inorganic salts by addition of the usual barium mixture, filter, and evaporate the filtrate to dryness; extract with common alcohol, filter, evaporate the filtrate, and allow the crystals of urea to form by adding absolute alcohol and setting aside to evaporate spontaneously. Another method is as follows: Evaporate the urine to a thin sirup, and add concentrated nitric acid in the cold, whereby the nitrate of urea is precipitated. These crystals are now treated with carbonate of barium, and the urea is extracted from the dried mass by means of alcohol.

Synthetically urea can be formed from cyanate of ammonium. We fuse 80 parts of anhydrous ferrocyanide of potassium with 30 parts of carbonate of potassium in a crucible, and the resulting potassium cyanide (KCN) is converted into potassium cyanate (KCNO) by oxidation with 150 parts of red oxide of lead at a gentle heat. The white melt is then thrown upon an iron plate. After cooling, the potassium cyanate (KCNO) is dissolved in a solution of 80 parts of ammonium sulphate ($(NH_4)_2\,SO_4$) to 500 parts of water. Then by decomposition we have ammonium cyanate and potassium sulphate ($NH_4\,CNO$ and $K_2\,SO_4$), filter, and evaporate the filtrate to dryness. During the evaporation the relation of atoms is changed, so that from the cyanate of ammonium urea is formed.



$$O\left\langle\begin{matrix} CN \\ NH_4 \end{matrix}\right. = CO\left\langle\begin{matrix} NH_2 \\ NH_2 \end{matrix}\right.$$

Cyanate of ammonium. Urea.

The mass resulting from the evaporation is then extracted with boiling alcohol, 100 grms. at a time, and allowed to crystallize.

Urea crystallizes microscopically in white, glistening needles, macroscopically in long, clear, four-sided prisms, the ends of which are terminated by one or two oblique planes. These are very soluble in water and alcohol, but insoluble in ether. By heating on platinum foil, ammonia is generated freely. If we add a solution of urea to a stale urine or to a secretion from bladder catarrh, in contradistinction to its synthetical formation, it decomposes (by taking up one molecule of water) to 1 mol. carbonic acid, and 2 mols. ammonia ($CH_4 N_2O + H_2O = CO_2 + 2NH_3$). This decomposition ensues when urea is boiled with mineral acids, fused with caustic alkalies, or heated with caustic baryta in a closed tube. With nitrous acid or with hypochlorite or hypobromite of sodium, the urea decomposes, forming carbonic acid, water, and nitrogen.

Mercuric nitrate gives with solutions of urea a white flocculent precipitate, which, according to the concentration and temperature of the fluid, contains two, three, or four equivalents of mercury to one of urea. Urea also enters into combination with chloride of sodium.

If we add pure nitric acid to a concentrated urine or a concentrated solution of urea, we obtain beautiful microscopic and often macroscopic rhombic tables.

If we only have a drop of a fluid containing urea to be analyzed, we add a drop of nitric acid on an object-glass, and after warming slightly set it aside to crystallize. With the microscope we see single rhombic or hexagonal plates, or we observe them in greater mass more or less perfectly formed, arranged in shingle-form layers, exhibiting their acute angles (nitrate of urea, Pl. III., A, 1). The acute angles are 82°. The proof by forming nitrate of urea is most frequently used, on account of the characteristic shape of the crystals.

With albuminuria the nitrate of urea crystallizes in penicillated needles. (K. B. Hofmann, "Zoochemie.")

Upon the addition of oxalic acid to a concentrated solution of urea, crystals are formed which in appearance resemble those of urea nitrate (Pl. III., A, 1); the former crystals, however, appear more irregular in shape than the latter. This reaction is only employed to confirm what has been already proven by the nitric acid test.

All tests for urea must be applied to concentrated urine. If albumen is present, it must be separated by coagulation and filtration, and the filtrate concentrated.

In order to determine that a given fluid is urine, the presence of urea and uric acid must be proved. If there are only a few drops of the fluid, the microscopical test for nitrate of urea is to be employed; but it must not be forgotten that transudates may also contain urea.

As urea is present in greater quantity than any other constituent of the urine, its percentage may be determined, at least approximately, from the specific gravity of the fluid, provided a normal amount of sodium chloride is present, no sugar, and no great quantity of albumen.

If the urine to be analyzed contains a normal amount of chlorides, neither albumen nor sugar, and has a specific gravity of 1·020–1·024, urea can be said to be present in normal percentage (2–2·5 per cent.).

If, under the above conditions, the specific gravity is higher or lower, there will be a corresponding increase or decrease in the amount of urea present. If the specific gravity is 1·014, the urine contains about 1 per cent. urea; if, on the other hand, the specific gravity is 1·028–1·030, the urine contains 3 per cent. urea.

If the chlorides exist in small amount or are inappreciable, as is sometimes the case with urine of acute fevers, and the specific gravity is normal, then urea exists in greater than usual percentage. For the chlorides have a second place (albumen and sugar excepted) in influencing the specific gravity, and if these are wanting and the specific gravity is 1·020, we know it is due to an excess of urea; for, even if all the other constituents were excreted in double quantity (as uric acid, creatinine, phosphates, and sulphates), they would have no appreciable influence on the specific gravity.

If albumen is present in but small quantity (up to 0·2 per cent.), which fact we can ascertain approximately by the nitric acid test, we need not take it into consideration; for, if the albuminous precipitate is not massive nor curdled, but white, cloudy, and translucent, it has no especial influence on the specific gravity. But, if the urine contains more albumen (1–2 per cent.), it must then be separated by coagulation and filtration. For this purpose it is best to take a certain quantity, say 50 c.c., and heat to boiling with a few drops of acetic acid, filter the urine from the coagulated albumen, and wash with distilled water until we have a volume of fluid equal to that at the beginning (50 c.c.). We then find the specific gravity of this urine freed from albumen.

Usually albuminous urines have a less specific gravity than the normal; because, through diseases of the urinary organs, the latter are unable to excrete the amount of solids (especially urea) that the healthy organs excrete, and consequently the specific gravity of the urine is less. As regards the specific gravity, excreted albumen is very seldom present in such quantity as to make up for the want of urea.

If sugar exists in great quantity in a urine, the percentage of urea is always diminished: although, in the total amount of urine excreted in twenty-four hours in diabetes, the absolute quantity of urea is increased. The high specific gravity of such urine depends upon the sugar.

Notwithstanding certain claims, up to the present time urea has not been formed artificially from proteine substances; but we must regard such substances as its only source.

Urea owes its origin in part to the retrograde metamorphosis of tissue (including the blood), and partly to the breaking down of the unassimilated nitrogenous principles. Whether it arises through gradual oxidation, whether its molecule is split off from a more complex molecule by a process of fermentation, whether it is a splitting up of the albumen molecule itself, or whether a gradual disintegration of the albumen molecules leads to the formation of smaller molecules from which urea results by oxidation, is up to this time undecided.

It is known that certain combinations of the uric acid group (uric acid, allantoine, creatine, sarkine, xanthine, guanine) and the known derivatives of the proteines (glycocoll, leucine, asparagine), when introduced in large amount, cause an increase in the quantity of the solids excreted.

Urea may under certain conditions be present in such amount that the simple addition of nitric acid to the urine forms a thick pulp of nitrate of urea. This may take place—

(1.) From a predominant animal diet.

(2.) In acute febrile processes, until the crisis of the disease. The urea arises in these cases from an increased disintegration of the nitrogenous elements.

(3.) In diabetes insipidus and diabetes mellitus.

[The amount excreted will also vary with the degree of mental and bodily activity.]

On the contrary, the amount of urea is lessened—

(1.) By a predominant vegetable diet, and by fasting.

(2.) By chronic disease, when the tissue-metamorphosis is checked (cachexies).

(3.) By parenchymatous nephritis, accompanied by uræmia, especially toward the fatal end (7 grms.).

The percentage of urea is diminished in urina potus, urina spastica, and diabetes. But in the whole quantity of urine passed in twenty-four hours the amount of urea is increased, or at least is normal.

2. *Uric Acid.*

Uric acid ($C_5 N_4 H_4 O_3$) is a constant constituent of the urine of the carnivora. From a healthy man 0·4–0·8 grm. is excreted in twenty-four hours.

It is soluble with difficulty in 15,000 parts of cold and in 1,800 parts of hot water, insoluble in alcohol and ether. It is from these circumstances that uric acid exists in but small quantities in the urine in a free state, but generally is found in combination as urates.

In a warm solution of the normal alkali phosphates, uric acid dissolves more readily than in water, because it takes up from the phosphates a part of the alkali, forming an acid alkali phosphate and an alkali urate.

Free uric acid as well as the urates (salts of uric acid) appear colored in the sediment, and the more intense their color the more highly is the urine colored.

In order to obtain uric acid from the urine, we add one part of HCl to 20 parts of urine, and let it stand twenty-four hours. It appears on the bottom and sides of the beaker as a fine powder, and on the surface of the urine as a film. The forms of the uric acid crystals are wedge- and whetstone-shaped; i. e., they are rhomboidal vertical prisms. (Pl. II., A.) It appears in these forms as a natural sediment. If the uric acid, however, is separated by means of hydrochloric acid (HCl), then the crystals are somewhat changed; they appear much thicker and more deeply colored.

Generally we find under the microscope either double wedges in cross form, or groups of thin and long wedges or needles parallel to one another, some of which resemble a comb with teeth on either side. Occasionally we find single long whetstone- or needle-shaped crystals. (Pl. II., B.) If we filter the solution containing the uric acid crystals precipitated by HCl, and dissolve the crystals in potassium or sodium hydrate (KOH, NaOH), and then precipitate again by HCl, the separated crystals are much whiter. Snow-white crystals may be obtained by repeating this process. (Pl. II., A.) The crystals of uric acid may also be purified by dissolving them in sulphuric acid (H_2SO_4) and precipitating by addition of much water.

In freshly passed urine we should never find a sediment of uric acid or urates. If we find this condition often, we must suspect stone or gravel. It happens frequently that with stone or gravel, uric acid may be excreted in the form of millet and flaxseed concretions, which are too large for a microscopic investigation, and therefore no sure diagnosis of their constitution can be made. In such cases we can very suitably prove the presence of uric acid in a chemical way by the murexide test.

*Murexide Test.**—For this test rub up the concretion in a small mortar, and throw into a porcelain dish; add a few drops of nitric acid (HNO_3) and a little water, and warm carefully over a flame until the uric acid has dissolved; then evaporate cautiously almost to dryness. Already during the evaporation we notice, if uric acid be present, onion-red streaks on the walls of the dish, which

---

[* This test can, of course, be applied to the urine itself by evaporating a few drops of it and treating the residue.]

vanish suddenly as that portion of the dish approaches the flame. If, when the fluid has evaporated nearly to dryness, we add a drop of ammonia to the residue, the whole interior of the dish becomes a beautiful purple-red color (murexide = acid purpurate of ammonia). If we add, on the other hand, a drop of concentrated KOH to the residue, we obtain a beautiful violet-blue. The murexide reaction depends on the fact that by the addition of HNO_3 and heat, first alloxan and then alloxantine is formed, which on adding ammonia becomes murexide.

Instead of the murexide test, we may also dissolve the powdered concretions in some caustic potash and precipitate with hydrochloric acid (HCl). We can easily distinguish the characteristic whetstone crystals of uric acid, if it be present, by placing the crystals immediately under the microscope.

If we have but a small quantity of fluid (say 5 c.c.) to test for uric acid, we place it in a watch glass with a fine linen thread, add a few drops of acetic acid, and let it stand twenty-four hours at a temperature of 15° R., and observe with the microscope whether uric acid has crystallized upon the thread.

If we add to an alkaline solution of uric acid a weak cupric sulphate solution, a white precipitate of a cuprous urate falls. If we add a concentrated cupric sulphate solution and boil, we obtain a precipitate of cuprous oxide free, as a red powder. In the latter case the oxide is reduced to suboxide, and the oxygen goes to oxidize the uric acid. (In the colorless solution we find, besides urea, allantoin and oxalic acid.)

Nitrate of silver in the cold is readily reduced by an alkaline solution of uric acid. When a drop of the silver nitrate on a filter paper is touched with the uric acid solution, there results (if there is contained $\frac{1}{1000}$ per cent. uric acid) a black or (if there is contained $\frac{1}{500000}$ per cent. uric acid) a brownish-yellow spot.

Uric acid in presence of an alkali is oxidized by ozone to urea, ammonia, oxalic acid, and carbonic acid; without an alkali, to urea, carbonic acid and allantoin.

Uric acid furnishes under the influence of various oxidizing agents, besides the customary urea, a great number of interesting decomposition products which may be regarded as ureas, in which the hydroxyl is replaced by an acid radical. The uric acid itself appears to contain the residues of two urea molecules.*

Uric acid is dibasic, and forms correspondingly two series of salts, neutral and acid.

The neutral salts are readily soluble in water, the acid salts with difficulty. One part of the acid urate of sodium is soluble in 124 parts of hot and 1,150 parts of cold water. Consequently, if we find salts of uric acid in the sediment, we know that they are the acid salts; on the other hand, if we have uric acid salts in solution after the urine has stood and is of the same temperature as the surrounding air, we know that the greater amount consists of neutral salts. This view is supported by the fact that when we add to such a urine a few drops of a strong acid, viz., HCl or HNO_3, the urine at first becomes turbid. If now we examine by the microscope, we find no characteristic uric acid crystals, but we see simply an amorphous punctiform mass, which consists of the acid urate of sodium. If we allow the urine containing the turbid cloud to stand for some time, the cloud gradually disappears, and in its place we find a distinct crystalline sediment of free uric acid. This reaction can not be more simply explained than that, having found neutral uric acid salts in solution, we have changed them to acid urates precipitated as a cloud, by the addition of an acid; for the added acid has taken up some of the alkali of the soluble neutral urates, and transformed it to acid urates. The acid by a longer action on these takes up the rest of the alkali, and the uric acid crystallizes.

---

* (K. B. Hofmann, "Zoochemie," "Abbildungen von Alloxan, Alloxantin, thionursaurem Ammon, Uramil, Parabansäure.")

It must be remembered that when the test for albumen is performed by pouring HNO_3 down the side of a wine glass, between the two fluids which do not mix there appears a thick white cloud, often mistaken for albumen, but consisting of amorphous acid urates, which by longer standing pass over into crystalline uric acid.

The acid urates of sodium and ammonium will be described later, in connection with the sediment. The causes of the increase or decrease in the amount of uric acid in the urine have not as yet been satisfactorily explained.

Uric acid is recognized as the first step in the formation of urea, although it is not probable that all the urea in the body passes through this stage. By the acceptance of this would be explained the increase of uric acid in all those cases where the oxidation of the nitrogenous products is insufficient; it may be that either too little oxygen has been introduced into the organism, or too much uric acid has been formed to be oxidized by the amount of oxygen present. There are many facts, however, not in accordance with this explanation.

Uric acid, as a derivative of proteine matters, has a similar significance to urea, as regards tissue-metamorphosis. We will therefore generally find an increase of uric acid where urea is excreted in greater than normal quantity.

We find, in accordance with this, an increase of uric acid—

(1.) From rich animal as well as vegetable diet, and too little exercise in the fresh air.

(2.) In acute febrile processes, which cause much breaking down of the nitrogenous elements of the body.

(3.) In lung and heart diseases, with dyspnœa.

(4.) In all cases where the diaphragm is impeded in its function, i. e., as with large tumors of the abdomen, ascites, etc.

(5.) In leucæmia, either with an increase of uric acid in the diseased spleen, or with diminished oxidation power of the red corpuscles, the carriers of oxygen—impoverished blood.

(6.) With the so-called uric acid cachexy.

A decrease of uric acid occurs usually in chronic affections of the kidney, diabetes mellitus (sometimes), urina spastica, hydruria, and arthritis.

The amount of uric acid in the urine may be approximately determined in the following way: Normal urine, of specific gravity 1·020–1·024, shows in the sediment neither uric acid nor the urates at the normal temperature, nor is there a precipitate with nitric acid.

If we concentrate a normal urine, we observe a small amount of free uric acid in the sediment, and by means of the nitric acid test a delicate layer of urates is seen. If in these cases the specific gravity is high, the urea is increased, as is also the uric acid. If we find with the normal amount of urine a considerable "brick-dust" sediment and also urates in solution, or if we find a considerable sediment of free uric acid, then the amount of uric acid may be considered as large. If the amount of urine is less than normal, we can not draw this conclusion. In this case we may have a sediment from the normal amount of urates, if the amount of water is not sufficient to hold them in solution at the usual temperature.

In general, whenever the urea is in less quantity, the uric acid is also diminished. All that has been said refers only to the percentage. If we wish to estimate the entire amount excreted, we must take into consideration the amount for twenty-four hours. It is most advantageous to compare with the normal urine. The average amounts to 1,500 c.c., and we have to add as much water to the concentrated urine as will bring the amount to this standard. If in twenty-four hours only 1,000 c.c. has been passed, we must add 500 c.c. of water, or what is the same thing, to every 10 c.c. of urine 5 c.c. of water. We pour into one of two narrow test-tubes 15 c.c. of normal urine, and into the other 10 c.c. of the urine to be examined and 5 c.c. of water, and, after adding 10 drops of HNO_3 to each, set them aside for twenty-four hours. From the amount of uric acid precipitated, one can easily estimate whether there is more or less uric acid precipitated in the urine to be tested than in the standard urine. If more than the normal amount of urine has been excreted in twenty-four hours, there must be a corresponding dilution of the standard urine.

[Garrod, in the Lumleian lectures for 1883,* takes strong ground in favor of the formation of uric acid by the kidney epithelial cells from nitrogenized material brought to them. He holds that uric acid exists in the kidney as urate of ammonium, and is converted into urate of sodium in the presence of excess of sodium salts in the blood and urine. He considers that the amount of uric acid in the urine is not increased by simple sugar (whether as glucose, cane sugar, or lactose), or fruits containing acid vegetable salts (as cherries, apples, and strawberries), or by light wines and distilled spirits, but is increased by sweetened fruit, heavy wines, and malt liquors. He attributes these results to "a ferment."]

3. *Coloring Matters.*

In normal urine there is a chromogenous matter (indican) and a pigment (urobiline); and several other well-characterized bodies are found in the urine, as well as one or more pigments which have not been satisfactorily isolated.

---

* "British Medical Journal," March 17, 1883, *et seq.*

a. Urobiline. Urobiline is a brown resinous mass which is easily soluble in water, more readily in alcohol, ether, and chloroform. The concentrated solutions are brown; by dilution they become yellow, and finally rose-red. They do not react upon litmus, show in reflected light a beautiful green fluorescence, and in the spectrum a dark absorption band between Fraunhofer's lines b and F. The fluorescence and absorption band become more distinct if we add to the solution some ammonia and a drop of chloride of calcium. By the addition of hydrochloric acid (HCl) the fluorescence vanishes. By acidifying the urobiline solution the absorption band recedes toward F, becomes paler, and shows more indistinct edges. If we add ammonia to the acid solution, the brown or red color changes to bright yellow with a greenish tinge. The alkaline solution shows the absorption band in the same place (if anything, nearer to b) as the original solution.

Dark fever urine is better suited for the separation of urobiline than normal urine. The latter involves too much work. We render the urine strongly alkaline with ammonia, filter after some time, and add chloride of zinc solution as long as a precipitate is formed; wash the precipitate upon a filter with cold, then with hot water, until nitrate of silver solution causes no turbidity; boil the mass with alcohol, dry at a gentle heat, dissolve the powdered mass in ammonia, and precipitate the solution with lead acetate; wash the precipitate with a little water, and take it up in a small amount of alcohol containing some sulphuric acid, and filter again. To the filtrate we add an equal volume of chloroform, and shake, adding fresh volumes of water to separate the sulphuric acid, until a color is perceived. The urobiline is obtained as a resinous mass by evaporating the chloroform.

Urobiline is, according to Maly, a reduction product of bilirubine. Hoppe-Seyler has succeeded in obtaining a product identical with urobiline (Maly's hydrobilirubine*) from the coloring matter of the blood, by treating with hydrochloric acid and tin. By injection of substances which cause the breaking up of the blood corpuscles, the formation of bile-coloring matters is promoted; so it is hardly to be doubted that urobiline is a secondary or direct reduction product of hæmoglobine, and that its increase possesses an interest for the physician. Such a condition is found in febrile processes, and indicates therefore a greater breaking down of the red blood corpuscles.

Urine which, on addition of ammonia and a little chloride of zinc solution, shows a green fluorescence and the characteristic absorption band, should be regarded as moderately rich in urobiline.

Scherer's urohæmatine, Heller's urophæine, Thudichum's urochrome, etc., are bodies for whose existence as proximate principles there is no guarantee. Maly has shown further that urochrome and urohæmatine both contain much urobiline.

---

* See "Annalen der Chemie," 163, p. 77, and Hofmann, "Zoochemie," p. 220.

β. *Indican.* More recently Heller has shown that, by the mixing of the urine with nitric acid, a peach-blossom red, violet, or deep-blue color appears. The red he ascribed to urrhodine, the blue to uroglaucine; and the base from which both arise, and which he regarded as a yellow coloring matter, he called uroxanthine. Uroglaucine is found in spontaneously putrid urine, in the sediment, or as a film on the surface. This has been recognized as indigo, in that it is identical with plant-indigo in all its peculiarities (crystallizing in needle form, subliming as a red vapor, and being deprived of color by reduction agents, as sulphate of iron).

Uroxanthine was regarded as identical with indican, a derivative from which is white indigo, which is found in some plants. Later investigation has rendered it probable that the indigo-producing substance of the urine differs from plant-indican. We will call it urine-indican.

If we do not desire a large quantity of pure urine-indican, we may precipitate fresh urine with neutral and basic lead acetate, treat the filtrate with ammonia, suspend this precipitate in alcohol, and permit a stream of hydrogen sulphide to pass through; filter from the sulphide of lead, and evaporate with a gentle heat, finally, over sulphuric acid *in vacuo.* The urine-indican thus obtained is a pale brown, bitter-tasting sirup. By a more complicated method we can obtain it in quantity. (Hoppe-Seyler, "Chemische Analyse," 4th edition, p. 191.)

The urine-indican is not a glycoside, as by splitting up (contrary to older writers) it yields no sugar (indi-glucine), but is a sulpho-conjugate compound of indol, because by addition of HCl a large amount of H_2SO_4 is liberated (Baumann). In a free state this acid ether is unstable, and decomposition as well as the action of mineral acids splits it up. In both these cases an oxidation takes place; consequently the formation of indigo does not consist in a simple breaking up. One product, as we have before shown, is indigo; the second is a red body, the sublimate of which condenses as fine red needles, and may be identical with Heller's urrhodine. On the different proportion of both decomposition products depends the color, which the addition of HCl to the urine brings about.

If concentrated sulphuric acid (H_2SO_4) is mixed with a double volume of urine (which should be dropped in from some height), the mixture assumes a more or less garnet-red color, probably due to various decomposition products.* When present, sugar, albumen, and biliary matters, as well as their decomposition products, undoubtedly take part in this color formation, in which case the mixture becomes quite opaque and dark brown. (Heller's urophæine test.)

[* If the patient has taken naphthalene, a green color may result. This fades to a dirty-gray or brownish-green.—BENZOLDT.]

By the mixture of H_2SO_4 with the urine, a strong heat is evolved, which causes the separation of several constituents, as iodine, the odorous oil of cubebs, and saffron, etc., which are perceived by the smell. In parenchymatous inflammation of the bladder a repulsive odor is developed.

There are many methods of proving the easy chemical decomposition of urine-indican in the urine. The oldest is the uroxanthine test of Heller, already mentioned.

(1.) *The uroxanthine test* is as follows: Pour 3 or 4 c.c. of pure HCl into a small beaker glass, to which while stirring add 10 to 20 drops of urine. In a normal proportion there exists only enough urine-indican in the urine to color the hydrochloric acid mixture a weak yellowish-red. A greater proportion colors the HCl mixture violet or blue. The richer a urine is in indican, the more intense will be this color reaction. Often one or two drops of urine suffice to color 4 c.c. of HCl a beautiful blue. If in one or two minutes no color appears, the urine-indican is not excessive, even if in ten or fifteen minutes a dark red-brown color appears.

If we wish to test an icteric urine for indican, we must first remove the bile-coloring matters by lead acetate, and test the filtrate for urine-indican, though some is lost by this method.

The color of the uroxanthine test has unfortunately little value, as it not only indicates the amount of urine-indican, but also its capability of decomposition, which seems to vary. How varying this is, is shown by the circumstance that the urine-indican contains sometimes more indigo-blue and sometimes more indigo-red. It must be observed also that albumen, when treated with HCl after standing a long time, or by heating, develops a violet color. The dark blue color, despite the faults that may be attributed to this method, can be regarded as a sure indication of an increase of urine-indican.

(2.) *Jaffé's test.*—Mix 10 c.c. of strong HCl with an equal volume of urine, add a drop of a saturated solution of so-called bleaching powder, or some chlorine water, and observe the color.

(3.) *Stokvis's test.*—Warm 5 c.c. of urine with twice the amount of common nitric acid (to 60–70° R.), and shake with chloroform, which takes up the indigo. The chloroform shows in the spectrum the characteristic band of indigo between C and D.

Here we will simply refer to an interesting method of E. Salkowsky (Virchow's "Archiv," Vol. 68, p. 407). If indol is introduced into the organism, the amount of urine-indican excreted will be increased. The same follows if the small intestine be ligated so as to destroy its permeability; for now by pancreatic digestion (in the latter stages) much indol will be formed. This is evidently reabsorbed into the blood from the ligated intestine, and is there changed into urine-indican, just as is the injected indol. The albumen of food is also a source of indican; for indol is one of the ordinary decomposition products of albumen. It is probable, on the other hand, that a portion of the albumen in the living body is decomposed by fermentation, just as outside the body it is destroyed in very much the same manner. The albumen of the tissues of the body is another source of indol, and consequently of indican. It is hence evident that by starvation indican does not disappear from the urine, because it is formed at the expense of the disintegrating tissues.

We find an increase of urine-indican after the introduction of indol, after an exclusively flesh diet, in Addison's disease, in cholera, and in carcinoma of the liver; and it is enormously increased in all those diseases which threaten closure of the small intestine (incarceration), but not so much by impenetrability of the large intestine. It is considerably increased with carcinoma of the stomach without the intestines being involved; also with peritonitis. With kidney diseases, except granulated kidney, the indican is not much increased; and with chlorosis and leucæmia there is no increase. In general there is an increase in chronic consumption and in inanition. Fevers do not cause so marked an increase of indican as of urobiline.

There is an increase of urine-indican in central and peripheral diseases of the nervous system, as well as after the administration of certain drugs, as turpentine, nux vomica, oil of bitter almonds, etc. This, however, is only demonstrated by the uroxanthine reaction, and requires confirmation by more accurate methods.

[M. Thoms (as quoted in the Boston "Medical and

Surgical Journal," August, 1882) reports that urine containing balsam copaiva gives, upon the addition of hydrochloric acid alone, or with the addition of a drop or so of nitric acid, a reddish-violet color similar to that produced in urine containing indican. In the former case, however, alkalies change the red color to green.]

4. *Other Normal Organic Constituents.*

The remaining organic constituents of the urine we will only mention in passing, for they are of little value in general diagnosis, because of the care required for their identification and separation.

Creatinine, the strongest recognized base of the body, is excreted in the same proportion as uric acid; for a sound man, 0·6–1·3 grm. in twenty-four hours. The amount is found to be less by a vegetable than an animal diet. It is increased in pneumonia, intermittent fever, and typhus, but diminished by inanition and advanced kidney affections.*

Hippuric acid is present in largest amount in the urine of herbivora, and in only small quantity in the human urine, being for a healthy man 0·5–1 grm. in twenty-four hours. The amount is increased by a vegetable diet, after the use of certain fruits (greengages, whortleberries, etc.), and after the use of benzoic acid, etc.; also in febrile processes and in diabetes. It is diminished by a strict flesh diet. If the excreted mass

---

[* It is diminished with paralysis, but increased if there is muscular agitation. Grocco, "Ladd. Med. Record," February 15, 1887.]

is considerably increased, as after eating greengages, and we then evaporate slightly and add HCl, hippuric acid will be precipitated in the same manner as uric acid. Otherwise we must employ the method of Meissner (Neubauer-Vogel, l. c. 43), for which a litre of urine is necessary.

Xanthine and the phenolsulphate derivatives are found in the urine, but in small quantity. For a quantitative determination of the first it is necessary to obtain several hundred litres of urine. The existence of the substance yielding phenol derivatives betrays itself by the phenol reaction of the distillate, if we previously acidify the urine with a strong mineral acid (e. g., H_2SO_4). From the fact that when we add tartaric acid and distil we have no phenol reaction in the distillate, we conclude that phenol (carbolic acid) does not exist normally in the free state in the urine.

We mention in passing that up to this time, from a derivative of uric acid, oxaluric acid has been found in but very small quantity (not less than a hundred litres must be used to test for it). Parabanic acid occurs as an oxidation product of uric acid, and by taking up water becomes oxaluric acid. This boiled with water forms oxalic acid and oxalate of urea.

Oxalic acid is found in the sediment as calcium oxalate.

In regard to the existence of sugar in normal urine, the point is as yet undecided. In every case normal urine contains besides the urates a body which in an alkaline solution will reduce the copper salts.

The assertion that lactic acid is present in normal urine needs confirmation. In pathological urine we find two kinds of lactic acid. One is present in fermenting diabetic urine (lactic acid); the other is found after phosphorus-poisoning, with acute atrophy of the liver, with osteomalacia and trichinosis (paralactic acid).

b. Normal Inorganic Constituents.

1. *Chlorides.*

In human urine the chlorides consist almost entirely of the chloride of sodium (NaCl) and a little chloride of potassium. The average excretion for a healthy man is 10 to 16 grms. of NaCl in twenty-four hours (6 to 10 grms. chlorine). Next to urea, NaCl is the principal constituent of the urine. Normal urine has an appreciably salty taste proportionate to the quantity of the contained NaCl. If a drop of urine is carefully evaporated on an object-glass, we find under the microscope, besides the colorless monoclinic prisms of the double compound of urea with chloride of sodium, also NaCl in flat octahedra or in imperfectly shaped crystals of the monometric system.

For the physician it is often important to ascertain quickly and easily whether in the urine the chlorides are increased or not. An approximative test is the following (for more exact determinations see Chap. V.):

If a chloride of sodium solution is treated with nitrate of silver, a white precipitate of chloride of silver will fall:

$$NaCl + AgNO_3 = NaNO_3 + AgCl.$$

If we have a solution in which both the chlorides and phosphates are present (viz., urine), we must first acidify with a few drops of nitric acid (HNO_3), so that the phosphate of silver will not be precipitated at the same time, and thereby be mistaken for the precipitate of chloride of silver. A slight error from the precipitation of uric acid can not be avoided, but it does not essentially affect this approximative examination.

The HNO_3 added will not prevent the precipitate of the chloride of silver ($AgCl$), but it will prevent the phosphate of silver from coming down. If we use for this reaction a solution of nitrate of silver of definite strength ($AgNO_3$), 1:8, we will find that, by adding a few drops of this to normal urine (which contains ½–1 per cent. $NaCl$), curdy masses of $AgCl$ will fall to the bottom. These masses do not separate on shaking the glass, and give no milky cloudiness. If the solution contains but a small quantity of $NaCl$, $\frac{1}{10}$ per cent. or less, the solution after addition of $AgNO_3$ shows no white curdy precipitate, but a simple cloud, and the entire fluid shows a homogeneous milky turbidity.

To apply this test, we take a wine-glass half full of urine, acidify with HNO_3 to prevent the phosphates coming down, and then add one or two drops of the standard $AgNO_3$ solution. If the reagent causes a curdy precipitate readily falling to the bottom, the chlorides are in no way diminished in quantity. If only a milky turbidity arises, and no curdy masses, then the chlorides are in very small proportion. If there is no milky cloud or turbidity, the chlorides are entirely wanting. We can not ascertain an increase of chlorides by this method.

This reaction can be seen in a urine that has been tested for albumen with HNO_3, using this mixture for the chloride test. The nitric acid must, however, be thoroughly mixed with the urine by means of a glass rod before adding the silver salt. But, if albumen has been found in such amount as to interfere with the cloud or precipitate of the chlorides, it must first be filtered off before testing with $AgNO_3$, and the test can be applied to the filtrate.

We find a smaller proportion of chlorides in the urine—

(1.) In repose of the body (in the night-time least).

(2.) With all acute febrile processes, especially when accompanied by serous exudation or watery diarrhœa. The mass of chlorides is directly proportional to the amount of urine, but inversely proportional to the specific gravity and the quantity of urea, until the crisis of the disease. In general only the excess of chlorides is eliminated by the kidneys. In inflammatory processes the chlorides appear in the exudates (for instance, in pleuritic effusions). In general the rule applies, that with a steady decrease of chlorides in the urine there is a heightening of the disease, and on the other hand a continued increase of chlorides signifies a better condition.

In pneumonia the chlorides may be entirely wanting, but we can not attribute this condition to lessened nutrition alone. In typhus and meningitis they are diminished, but do not disappear. The absence of chlorides always signifies a desperate condition.

(3.) In chronic affections accompanied by impaired digestion, and in dropsy.

In urina potus the percentage of chlorides is diminished; but, if we take the twenty-four hours' amount into consideration, the diminution is inappreciable.

An increase of chlorides is observed—

(1.) With a liberal salt diet.

(2.) With energetic bodily or mental exercise.

(3.) In the paroxysms of intermittent fever, sometimes a little before or after the same. The day after we find the average daily amount sometimes a little less.

(4.) With diabetes insipidus.

(5.) With dropsy, as soon as diuresis comes on, for now the chlorides stored up in the body become suddenly excreted.

2. *Phosphates.*

The amount of excreted phosphoric acid (not phosphates) is between 2·3 and 3·8 grms. (average 2·8). In robust men the average is 3·5 grms. The daily variation may be very considerable. The amount excreted increases after breakfast until evening (maximum), and falls during the night till the next morning (minimum).

We find an increase of phosphoric acid in the urine—

(1.) After the introduction of phosphorus, phosphoric acid, or soluble phosphates into the organism.

(2.) After a principally animal diet, and especially after the administration of such substances as contain more or less phosphoric acid, as the brain.

(3.) With all acute febrile diseases (not constant).

We find a decrease of phosphoric acid—

(1.) In all urines of a low specific gravity, in urina potus, in urina spastica, etc.

(2.) In kidney and heart diseases, with a less amount of urine.

(3.) With severe disorders of the digestion, and with chronic diseases of the brain (except epilepsy).

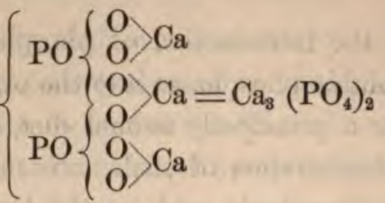
Orthophosphoric or ordinary phosphoric acid (H_3PO_4) is a tribasic acid; that is, the three atoms of hydrogen may be replaced by a metal.

In the urine phosphoric acid is combined partly with the alkaline earths (earthy phosphates) and partly with the alkalies (alkali-phosphates).

a. The earthy phosphates—viz., calcium and magnesium phosphates—exist in normal urine only in small quantities. The twenty-four hours' average for a healthy, robust man amounts to 0·9–1·3 grm. The proportion of the calcium to the magnesium phosphate is as 33:67; that is, the amount of magnesium is double that of the calcium phosphate. In acid urine these salts are in solution, but in alkaline urine they are precipitated, and are found in the sediment.

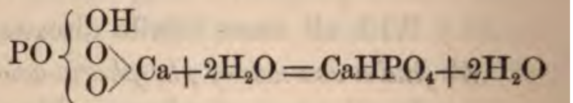
Phosphoric acid forms with calcium three salts, viz.:

The normal or tricalcic,



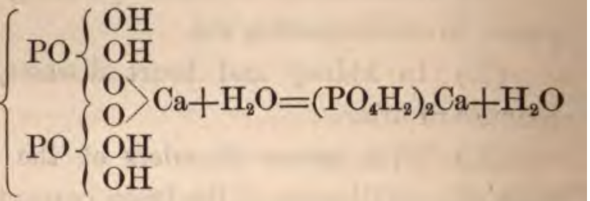
$$\left\{\begin{array}{l}\mathrm{PO}\left\{\begin{array}{l}\mathrm{O}\\ \mathrm{O}\\ \mathrm{O}\end{array}\right.\\ \mathrm{PO}\left\{\begin{array}{l}\mathrm{O}\\ \mathrm{O}\\ \mathrm{O}\end{array}\right.\end{array}\right. \begin{array}{l}>\mathrm{Ca}\\ >\mathrm{Ca} = \mathrm{Ca_3}\ (\mathrm{PO_4})_2\\ >\mathrm{Ca}\end{array}$$

The dicalcic phosphate,



$$\mathrm{PO}\left\{\begin{array}{l}\mathrm{OH}\\ \mathrm{O}\\ \mathrm{O}\end{array}\right. >\mathrm{Ca}+2\mathrm{H_2O}=\mathrm{CaHPO_4}+2\mathrm{H_2O}$$

The monocalcic or superphosphate,



$$\left\{\begin{array}{l}\mathrm{PO}\left\{\begin{array}{l}\mathrm{OH}\\ \mathrm{OH}\\ \mathrm{O}\end{array}\right.\\ \mathrm{PO}\left\{\begin{array}{l}\mathrm{O}\\ \mathrm{OH}\\ \mathrm{OH}\end{array}\right.\end{array}\right. >\mathrm{Ca}+\mathrm{H_2O}=(\mathrm{PO_4H_2})_2\mathrm{Ca}+\mathrm{H_2O}$$

In the urine we find this last combination dissolved—no monomagnesic phosphate is known. In the urine the dicalcic and magnesic phosphates are held in solution by free acid (?).

The precipitation of the earthy phosphates is brought about by the addition of the alkalies (potassium, sodium, and ammonium).

The reactions of the salts are as follows: If alkalies be added to calcium phosphate, it will be deprived of some of its acid:

$$3[(\mathrm{PO_4H_2})_2\mathrm{Ca}]+12\mathrm{KOH}=$$
$$(\mathrm{PO_4})_2\mathrm{Ca_3}+4\mathrm{K_3PO_4}+12\mathrm{H_2O}$$

If acid magnesium phosphate is acted upon by ammonia, an ammonium-magnesium phosphate is formed:

$$MgHPO_4 + NH_3 + 6H_2O = Mg(NH_4)PO_4 + 6H_2O$$

Ammonium-magnesium phosphate formed in this way appears under the microscope as fern-leaved or snow-flake crystals; after long standing in the glass, these crystals become coffin-lid-shaped. (Pl. III., B.)

To test for the earthy phosphates, we fill a test-tube one third full—if it was not clear with previously filtered urine—add a few drops of KOH or $(NH_4)OH$, and warm until the earthy phosphates separate out as a flocculent precipitate. After setting aside for ten to fifteen minutes to settle, we can approximatively estimate the amount. If we employ for the reaction an ordinary-sized test-tube, 16 centimetres long and 2 c. wide, a layer of earthy phosphates 1 c. high corresponds to the normal amount in the urine; if the layer is 2–3 c. high, then are the earthy phosphates increased; if, on the contrary, only single flakes appear, then the earthy phosphates have diminished.

Beneke gives a more accurate method of determination (Neubauer-Vogel, "Analyse des Harnes," Ed. vii., p. 91, 1).

If the urine contains no abnormal coloring matters, the earthy phosphates are white; if abnormal coloring matters are present, they are variously colored. If the urine contains blood-coloring matters, then the precipitate appears blood-red or dichroic; with the plant-coloring matters of rheum, senna, etc., rose-red to blood-red;

with bile-coloring matters, yellow-brown; with uroerythrine, gray.

An increase of earthy phosphates in the urine is found with disease of the bones, especially when diffuse (osteomalacia, rachitis, etc.), with diffuse periostitis, and with chronic or arthro-rheumatic processes; further, after use of mineral waters rich in calcium, after various medicaments, and with exclusive flesh diets (in the latter case not constant).

A decrease of earthy phosphates is observed in kidney affections. In alkaline urine we naturally find the earthy phosphate in the sediment.

β. *The alkali phosphates* are represented chiefly by the acid phosphates of sodium and (traces of) potassium. The tribasic phosphoric acid forms three salts with the alkalies, in which one, two, or three atoms of hydrogen are replaced by the alkali metals—

PO_4H_2Na	PO_4HNa_2	PO_4Na_3
Monosodic or Acid sodium } phosphate.	Disodic or Neutral sodium } phosphate.	Trisodic or Basic sodium } phosphate.

Of these three, only the first has an acid reaction, and its presence in the urine causes more than any other constituent the acid reaction of the same. Both the others have an alkaline reaction. All three are (in contradistinction to the earthy phosphates) easily soluble in water and alkaline fluids.

Of the total phosphoric acid in the urine, two thirds is in combination with the alkalies.

We test for the alkali phosphates (chiefly for the phosphoric acid) in the urine with the magnesium mixture. (See Chapter IV., No. 10.) If we test for the entire amount of phosphoric acid—that is to say, not only that in combination with the alkalies, but also with the alkaline earths—we take a beaker of 20 c.c. capacity, and to 10 c.c. of urine we add a third part (usually 3 c.c.) of the magnesium mixture. There is formed a precipitate of crystalline ammonium-magnesium phosphate (fir-twig or snow-flake), with which comes down an amorphous mass of calcium phosphate. If there ensues through the entire fluid a milky turbidity, the alkali phosphates are in normal amount; if we have a copious precipitate which gives the fluid the appearance of cream, then there is a great increase; if the fluid remains transparent, or only a slight turbidity ensues, we have a decrease of the alkali phosphates.

This reaction is more for the whole amount of phosphoric acid in the urine than for the alkali phosphates. As the earthy phosphates only seldom occur in large amount in the urine, it is usually not considered necessary to separate them by filtration before testing for the alkali phosphates. If we have previously tested with KOH or (NH_4) OH, for the earthy phosphates, with a little practice we can easily distinguish the others from the turbidity caused by the precipitation of the earthy phosphate. If the earthy phosphates are present in great amount, we must precipitate them with ammonia, filter, and test the filtrate with the magnesium mixture.

3. *Sulphates.*

The sulphates contained in the urine are the neutral sulphates of potassium and sodium.

As the sodium salts predominate in the animal organism, so is there in the urine more sulphate of sodium (Na_2SO_4) than sulphate of potassium (K_2SO_4). The sulphuric acid which a sound man excretes in twenty-four hours amounts to 1·5 to 2·5 grms., usually 2 grms.

The test for sulphuric acid or the sulphates is made quite similarly to that for the phosphates.

Take 10 c.c. of urine in a beaker and acidify with a few drops of HCl (so that the barium phosphate will not precipitate at the same time), and add a third part (3–4 c.c.) of the chloride of barium solution. We have the reaction—

$$\underline{\mathrm{Ba}\,\overline{\mathrm{Cl}_2 + \mathrm{Na}_2}\,\mathrm{SO}_4} = 2\ \mathrm{NaCl} + \mathrm{BaSO}_4$$

If we had not previously added HCl, then the sodium phosphate in the urine, by the addition of $BaCl_2$, would be precipitated as barium phosphate.

If we have previously added an excess of HCl to the $BaCl_2$ solution, it is not necessary to acidify the urine before testing. (Chapter IV., No. 7.) The white precipitate which is formed by the $BaCl_2$ solution is the sulphate of barium.

If an opaque milky cloudiness results from this reaction, the sulphates are present in normal quantity.

If the cloudiness is more intense, so that the urine has the appearance of cream, the sulphates are increased. If, on the contrary, a translucent light cloudiness ensues, then the sulphates are diminished.

A very pretty approximate test has been given by J. Vogel. The normal urine should contain in twenty-four hours about 2 grms. of $H_2 SO_4$. If a patient passes 2,000 c.c. in twenty-four hours, this should contain 2 grms., or in 100 c.c. of urine 0·1 grm. $H_2 SO_4$. Take now 100 c.c. of this urine and add as much $BaCl_2$ solution as is necessary for the precipitation of half the sulphuric acid (0·05 grm.) and filter. If the filtrate remains clear after the addition of $BaCl_2$, there is no more $H_2 SO_4$ present; the amount of the latter is therefore very much diminished. If a cloudiness ensues after adding $BaCl_2$ to the filtrate, add as much $BaCl_2$ as will precipitate 0·05 grm. of the acid and filter again. If the filtrate remains clear after a fresh addition of $BaCl_2$, then the amount is normal, for we have taken as much $BaCl_2$ as would be necessary to precipitate $0{\cdot}05 + 0{\cdot}05 = 0{\cdot}1$ grm. (the normal amount) of sulphuric acid. If, however, a turbidity ensues, there is more than the normal amount of $H_2 SO_4$ present.

An increase of the sulphates or sulphuric acid is observed—

(1.) After an exhibition of sulphuric acid or the soluble salts of the same, and from sulphur-containing compounds or sulphur.

(2.) From exclusive flesh diet, for the sulphur of the albuminous compounds is oxidized to $H_2 SO_4$.

(3.) In acute febrile processes with rich excretion of urea. The increase of $H_2 SO_4$ in this case is referred to the increased decomposition of the sulphur-containing principles of the body (albuminates). The greatest increase is observed in meningitis, encephalitis, and rheumatism, as well as affections of the muscular system.

A decrease of the sulphates occurs with an exclusive vegetable diet, as well as at the beginning of typhus, and besides (in percentage) in all those urines which show a low specific gravity.

Of the inorganic substances, there are present in the urine ammonia (average 0·8 grm.) and traces of iron and silicic acid. According to Duchek, the former is increased by advance of febrile processes, and diminished by convalescence.

c. *Abnormal Constituents.*

1. *Albumen.*

In normal urine albumen should never exist; but in pathological urine, especially when accompanied with diseases of the kidney, albumen is often present in considerable quantity.

[In view of the very numerous cases recently recorded in which, without apparent disease, albumen has been discovered in the urine, following not only severe muscular exertion (long marches of soldiers, fencing, boxing, climbing, and other athletic exercises), or shower-baths, or even ingestion of food, it seems to us that this statement is too positive. Indeed, recent investigations and our own experience incline us to the view, so ably advocated by Senator,* that albumen always exists in normal urine, but in such exceedingly small quantity, and in such extreme dilution, as to render its detection by our present methods frequently impossible. With the increasing delicacy of our methods its detection is the more frequent.]

After an abundant use of egg-albumen, according to Cl. Bernard, Becquerel, and others, the same has been found in normal urine. Serum-albumen in very small quantity (to 0·1 per cent.) may appear even for a year in the urine of otherwise healthy men without occasioning any annoyance. We have observed many such cases ("Wiener med. Presse," 1870), as has Vogel. If this albumen had not been accidentally discovered in the urine, the affected persons would never have discovered it from their general condition. The cause of this albuminuria is still somewhat obscure. The urine in these cases was strongly concentrated, intensely acid, and contained a greater percentage of urea and uric acid. In the sediment sometimes nothing, but often crystals of oxalate of calcium and uric acid, could be discovered. It is probable that this albuminuria, which is for the most part periodical and with a very variable amount of albumen, is to be explained by the changed chemical characteristics of the urine. It is possible, besides, that an abnormal innervation of the kidney may give rise to this albuminuria. These cases occur

---

[* Senator, "Albuminuria in Health and Disease," and Appendices. "New Sydenham Society Publications" for 1884.]

so rarely, however, that the appearance of albumen in the urine may be regarded as no normal indication.

Why we find no albumen in normal urine may best be explained by Ludwig's mechanical theory of the urine secretion. This is based, on the one hand, upon the relation of the pressure in the blood-vessels to that in the urinary tubules, and on the other, upon the osmosis of substances through animal membrane.

Graham divides all bodies into crystalloids and colloids, calling those bodies crystalloids which penetrate animal membranes without difficulty, and easily crystallize, and those colloids which penetrate with great difficulty or not at all, and do not crystallize. If we apply this classification to albumen, and especially to serum-albumen, we find that it is a colloid body, for it neither crystallizes nor penetrates animal membrane except under great pressure. As the crystalloid substances easily penetrate animal membranes and the colloids do not, it is to be supposed that the cause lies in the molecular constitution; that perhaps the molecule of albumen is greater than that of any soluble salt. This theory gains probability if we observe the constant foam on an albuminous solution, as also the complex chemical composition of the same. We find the extraordinary size of the albumen molecule in the expression of its atomicity, $C_{216}H_{169}N_{27}S_3O_{68}$.

According to Ludwig's theory, the secretion in the glomeruli is a transudation process, and in the urinary tubules a diffusion process. We find that in the kidney the blood is always separated from the urine by an animal membrane. These animal partitions permit the crystalloids of the blood (as salts, urea, etc.) easily to penetrate; but the colloids (albumen), under a normal blood-pressure, can not pass through, and on this account we find no albumen in normal urine.

If we find albumen in the urine, then the blood-pressure in the renal vessels is generally increased (hindered venous circulation, heart disease, amyloid degeneration of the vessels, etc.), or the animal membrane is defective in some place (parenchymatous nephritis and Bright's disease).

Of albumen, we chiefly find in the urine serum-albumen and paraglobuline. If to the urine are added other albuminous animal fluids (e. g., blood, pus, exudations, etc.), we find the variety of albumen corresponding to these fluids. Fibrine comes with intense hæmorrhage and with croupous affections of the urinary apparatus.

A true fibrinuria—that is, a coagulable urine—which occurs on the Isle of France, is seldom observed with us. We mentioned this in three cases of villous tumors of the bladder (p. 42). We often observe a honey-like, sirupy urine, the thick consistence of which is not due to fibrine, but to pus dissolved in the alkalies. Such urine becomes thinner on addition of water; and if we treat the same with acetic acid, there falls a white precipitate of alkali albuminate. This albuminate arises from the reaction of carbonate of ammonia on the serum-albumen of the pus.

For albumen there are many characteristic reactions, but for the urine there are two most satisfactory ones, the concentrated nitric acid (HNO_3) and the heat tests.

1. For the HNO_3 test 10 c.c. of urine should be taken in a wine-glass, and then pure colorless concentrated HNO_3 (not fuming) should be allowed to flow down the side of the glass, forming a layer beneath the urine. Now, if albumen is present, a white zone will appear between the two fluids. This can only be confounded with the urates which are precipitated in a somewhat similar manner when present in great amount, also with the resin of copaiva. In the case of the urates they are not precipitated in the zone between the fluids, but somewhat higher up, and are not sharply defined as a zone, but curl upward from the centre, having the appearance of ascending smoke.

If albumen and much urates are present in a urine at the same time, we obtain by the nitric acid reaction two layers, one above the other. The lower layer, sharply defined above and below, between the colorless acid and the urine, is the albumen. The upper layer, gradually becoming more intense and not sharply defined above, but ascending as a white cloud, consists of the urates. A layer of clear urine separates these two. The layer produced by the resin of copaiva disappears on the addition of a few drops of alcohol.

If we apply the nitric acid test to normal urine, we observe between the acid and the urine a brown ring of urine-coloring matters, which in a few minutes becomes more voluminous. In febrile processes, when the urine contains much coloring matter, this ring is very intensely colored. As albumen when present appears in the same zone, this does not form now as a white layer, but is more or less tinged with brown. If much indican is present, the urine often appears a beautiful rose-red or even violet; from the presence of blood-coloring matters, brown-red; from undecomposed bile-coloring matters, a beautiful green. If a urine is strongly concentrated and we add HNO_3, a copious crystalline precipitate of nitrate of urea falls, which under the microscope shows the characteristic colorless rhombic tables. From a urine rich in uric acid we often see beautiful shining light yellow-colored whetstone crystals, which can be easily distinguished micro-chemically from nitrate of urea, because they are not soluble in water.

If the urine contains much carbonic acid, either because it is alkaline and contains much ammonium carbonate, or because it has a neutral or even acid reaction and contains much sodium carbonate or free carbonic acid (as is the case from use of alkaline and carbonated mineral waters), we observe that the fluid by addition of HNO_3 becomes sparkling and sometimes even effervescent.

If there is doubt about the presence of albumen, then we must employ the heat test. It is always well to do both.

2. *The boiling test.*—If the urine is acid, we take 8–10 c.c. and boil in a test tube; it is safer, however, to add previously one or two drops of acetic acid. A flocculent cloudiness after boiling indicates albumen.

If the urine is but feebly acid, is neutral, or has an alkaline reaction, it is possible that a precipitate may form upon heating, which is again dissolved by the addition of acetic acid. This precipitate is not albumen, but consists of calcium carbonate mixed with earthy phosphates which were held in solution by carbonic acid; the carbonic acid being driven off by the heating allows them to precipitate (Heller's bone dust). What may happen with acid urine is much more liable to occur with neutral or alkaline; it is therefore best to acidify, to avoid confusion.

In making the boiling test with alkaline urine, the unpracticed may be easily misled as to the presence of albumen. The HNO_3 test succeeds here with difficulty or not at all, because of the brisk effervescence occasioned by the separation of the carbonic acid gas from the ammonium carbonate. If the urine is not acidified and contains a small quantity of albumen, the alkali is sufficient to change the albumen to an alkaline albuminate, which is not coagulated by heat. If acetic acid is not carefully added, but on the contrary an excess has been used, an acid albuminate may form, which is also not coagulated by heat. A small amount of albumen is with difficulty recognized if the urine is turbid and remains so after filtration. Alkaline urines are always more or less cloudy, and contain for the most part no earthy phosphates in solution. Such urine must be cleared up before testing for albumen. For this purpose it must be boiled with a quarter of its volume of KOH solution and filtered. (Chapter IV., No.

5.) Should the filtrate not be quite clear, we must add one or two drops of the magnesium mixture, warm again, and filter. This filtrate always appears clear and transparent. If we carefully acidify now with acetic acid, we observe a slight cloudiness from albumen, though this will show more distinctly if to the fluid, after acidifying with acetic acid, we add a few drops of a solution of potassium ferrocyanide without warming, shake, and permit the sediment to settle for a few minutes. We observe now on the bottom of the test-tube the white flakes of precipitated albumen.

It is well to know a few other tests.

a. Acidify strongly with acetic acid, and add to the urine its volume of a cold saturated sodium-sulphate solution and boil.

b. Drop into a perfectly clear urine a cold saturated picric acid solution. If a white cloud forms, then is albumen present. (Galippe's test.) The cloudiness only lasts for a moment.

Albumen is found in the urine—

(1.) When the blood-pressure in the glomeruli becomes greater than normal. This occurs in all disturbances of the circulation, as heart-disease, impeded venous circulation, amyloid and atheromatous degeneration of the blood-vessels, etc.

(2.) In all those diseases which involve an alteration of the diffusion membranes of the kidney; i. e., the walls of the tubules with their epithelium, and the neighboring fine arteries or their capillaries (parenchymatous nephritis, Bright's disease, etc.).

(3.) If blood, pus, or any other albuminous fluid i mixed with the urine (false albuminuria).

(4.) Sometimes with hydræmia (imperfect nutritio of the capillary walls).

[(5.) With functional disorders.]

It is also said (Vogel) that albuminuria may resul from a peculiar albumen that is formed in the blood which penetrates the intact membranes by quite anothe diffusion process. But such a form of albuminuria w have never had an opportunity of observing.

In true albuminuria it is important to observe th amount of urine passed in twenty-four hours, for onl by an increase or decrease of the contained albume can a better or worse condition of the kidney disease b recognized. The most accurate quantitative determination of albumen is made by means of the balance, o by the employment of a polarization apparatus (Chapter V.). These methods are too troublesome for th practicing physician, but there remains a method b which it may be readily discovered whether albume exists in small (under ½ per cent.) or in great (1–2 pe cent.) quantity. With a little experience one can estimate approximatively the percentage from the appearance of the white albumen zone which forms betwee the fluids on the addition of the strong nitric acid. If this zone is faint and feebly white, and has no lump appearance, but is almost transparent and only visibl as a sharply-defined band on a black background, having the height of but 2–3 mm., we may say that albumen is only present in small amount (less than ½ pe cent., usually $\frac{1}{10}$ per cent.). If this zone appears from 4 to 6 mm. high, snow-white, opaque, and distinctly recognizable without a black background, and of a flocculent appearance, then albumen is present in considerable quantity ($\frac{1}{4}$–$\frac{1}{2}$ per cent.). But if on the addition of the acid the albumen appears lumpy and flaky, and more or less falls to the bottom, and by stirring with a glass rod the urine becomes of a creamy consistence, then albumen is present in large amount (1–2 per cent. and more).

We can make a similar investigation with the boiling test. Take a test-tube, fill it a third full of clear, filtered urine, and heat it. Should the urine be alkaline, it must be acidified with acetic acid. A slight turbidity after heating, the urine still being transparent, with only a feeble opalescence, indicates a small amount of albumen, and only after long standing a light flocculent sediment forms. If the urine becomes cloudy by heating, and the albumen separates out as flakes, and a layer comes down on the bottom the thickness of a finger, then albumen is present in moderate amount. If albumen is precipitated in large lumps, and not, as in the other cases, near the surface of the fluid, but lower down where the flame surrounds the test-tube, and appears to be of a creamy consistence, then albumen is present in great amount. If we would compare the amount of albumen one day with another, we must boil a like quantity of urine in similar test-tubes, and compare the mass of the sediment after it has well settled. It is more advantageous to employ glass tubes of uniform calibre, stopped at the lower end with corks covered with waxed paper, presenting a level surface, measuring the height of the precipitate at the expiration of twenty-four hours.

These are only a few suggestions for the practicing physician, but he must be very familiar with the characteristic reactions in order to draw satisfactory conclusions from the latter tests.

What has been said above applies to those cases in which the albumen is serum-albumen.

[Acid albumen or syntonin, and alkali albumen or casein, may occur in the urine when it is strongly acid or alkaline. Neither of these is excreted as such, but they are produced by the action of acid or alkali in the urine upon ordinary albumen (Ralfe). They are non-coagulable by heat, and hence may be overlooked; but they may be reconverted into ordinary albumen by the action of alkali or acid respectively.]

Frequently other modifications of albumen occur, of which the most important is globuline (perhaps myosine).

In order to prove the presence of globuline in the urine, it must be diluted until it has a specific gravity of 1·002; then add very carefully diluted acetic acid (for globuline is soluble in concentrated acid); usually a cloudy turbidity results. In order to precipitate all the globuline, we must pass a stream of carbonic acid gas slowly through the solution for from one to two hours. After standing some time, the globuline falls as a white powder. After pouring off the supernatant fluid, it can be tested for albumen by the above methods. If the sediment consists of globuline, it will dissolve in a few drops of a concentrated sodium-chloride solution. The test is best made in a wine-glass or decanting-glass. (For further consideration of myosine and paraglobuline, see K. B. Hofmann, l. c., 73 and 323.)

Globuline is observed in great quantity in bladder catarrh, acute nephritis, and especially in amyloid-degenerated, or waxy kidney; while from chronic Bright's disease it may be very small in quantity or entirely wanting. [It has also been found with albuminuria apparently dependent upon disturbance of the digestive organs.]

Peptone is contained in every albuminous urine. In those cases where the temperature is very high, it may occur without other albumen in the urine.

[Peptone may occur in normal as well as in pathological urine, and its clinical significance has not been definitely ascertained. Von Jaksch diagnosticated the rupture of the sac and suppuration in a case of ovarian tumor from its presence; but Grocco denies that it can be used as a means of diagnosis between simple and purulent exudation. It occurs in two groups of cases—general and local. In the former (including scurvy, typhus, diphtheria, tertiary syphilis, small-pox, cerebrospinal meningitis, phosphorus poisoning, etc.) it seems to be connected with a disorganization *en masse* of the leucocytes; in the latter (including pleurisy, croupous pneumonia, chronic bronchial catarrh, acute inflammatory rheumatism) it is associated with the resorption of an exudation rich in cellular elements. Its amount depends upon the character of the exudation (abundance, richness in globules, more or less rapid disorganization, and resorption), and the extent of surface and permeability of the walls containing the exudation. Indeed, it may appear in the urine (with or without serum-albumen) whenever, from imperfect digestion or other cause, it occurs in the blood. It also appears (Ralfe) from excessive formation of young cells along the genito-urinary tract. Decomposing albumen in the urine itself is another source. Inasmuch as it may be chemically mistaken for albumen, it is well to know some of its reactions. It is not coagulated by heat or nitric acid, nor is it precipitated by acetic acid and ferrocyanide of potassium. It is, however, precipitated by alcohol, tannic acid, potassio-mercuric iodide, metaphosphoric and picric acids, acidulated sodium chloride solution, and phospho-tungstic acid (or sodium tungstate), and it gives a rosy-red color with alkaline solutions of cupric sulphate. Randolph's test (Philadelphia "Medical News," May 10, 1884) has not proved satisfactory in our hands. Probably the best method for detecting it is that of Hofmeister,* which is, however, too complicated for ordinary clinical use. For a recent *résumé* of the subject, see Thèse, "De la Peptonurie," par Ch. E. Noury, Paris, 1884.

Hemi-albumose, or pro-peptone, a product of gastric and pancreatic digestion, and intermediate between albumen and peptone, has been detected in the urine several times of late, and deserves notice. It was first found as a constituent of urine by Bence Jones in a case of osteo-malacia, and in another case of the same disease by Kühne. Virchow discovered it in the medulla of osteo-malacic bones, and Fleischer in the normal bone medulla. Stokvis found it in the urine of a dog, into whose rectum he had previously injected it; and Lassar found it in the urine of rabbits after having rubbed petroleum into their skin. Senator found it in seven cases, one each of tertiary syphilis, hemiplegia, double pneumonia, diphtheria, carcinoma, single pneumonia, and muscular atrophy. In the latter case, however, there had been diphtheria four years previously, with dysentery and hæmorrhagic nephritis as sequelæ, and later neuritis of the left brachial plexus, with consequent paresis and atrophy of the arm. Pro-peptone has also been found in the blood during digestion, and also in pus. It is not coagulated by heat nor the addition of nitric acid to its hot solution; it is precipitated, however, by nitric acid (in the cold) and by acetic acid, with potassium ferrocyanide, or a strong solution of sodium chloride. It also gives the biuret reaction. It may be isolated (Tyson) from urine by acidulating with acetic acid, adding one sixth volume of concentrated sodium chloride solution, boiling and filtering. If, on cooling, the filtrate becomes turbid, with or without the further addition of sodium chloride, and the turbidity disappear on heating to reappear on cooling, pro-peptone is present. If desired, the second precipi-

---

* "Zur Lehre von Pepton," "Zeit. für phys. Chemie," Bd. IV., p. 256.

Oil. W.

tate may be filtered off, dissolved in a little water, and reprecipitated with acetic acid and potassium ferrocyanide.

Owing to the importance of mucin as a source of error in testing for albumen, especially with the later and more delicate tests, it is appropriate to say a few words regarding it in this place (for further particulars see under "Sediment," p. 165). Mucin is a substance closely allied to the albuminoids, but contains no sulphur. It is the active constituent of mucus, and is contained in greater or less quantity in all urines. In normal urines it is present in very small quantity, and in a state of suspension or false solution. Its appearance in abnormal quantity, without albumen, has little clinical significance, except as indicating a slight inflammation of some part of the genito-urinary tract. It is not coagulated by heat, and is soluble in the alkalies and strong mineral acids, and in water (false solution). It is precipitated by alcohol, all organic acids (including picric, Oliver), and dilute mineral acids; an excess of the latter will, however, redissolve the precipitate. In order to get rid of this disturbing element, when using the more delicate tests for albumen, it is best to add acetic acid (in the proportion of two drops to 10 c.c. of urine), as long as there is resulting turbidity, set the test-tube aside for an hour or so, and filter through double filter-paper before adding the reagent.

Pepsin, trypsin, and a diastatic ferment have been found in normal as well as pathological urine.

The following reagents, enumerated in the order of their delicacy, have received extended professional attention since the first edition of this work.

Potassio-mercuric iodide was first introduced by M. Ch. Tanret, of Troyes, in 1872, and is an exceedingly delicate reagent for detecting albumen. The basis of its reaction is the precipitation of albumen in an acid solution by the double iodide of mercury and potassium. The test liquid consists of *potassium iodide, 3·22 grms.; mercuric chloride, 1·35 grm.; distilled water to 100 c.c.; and, as a confirmatory solution, a 1 per cent. solution of mercuric chloride.

The test may be used qualitatively or quantitatively.

For qualitative testing add one or two drops of acetic acid to 10 c.c. of urine under stirring (if a decided turbidity result, filter), and then add the reagent drop by drop. If albumen be present, a white, opaque, flocculent precipitate will form, and will not be dissolved in excess of reagent.

The quantitative test is very simple, and is as follows: To 10 c.c. of urine add two drops of acetic acid as before, and then add the reagent drop by drop (from a pipette which will give a drop of 0·05 grm.), stirring carefully each time until the precipitate is no longer resolved in the albumen in excess; then, after each drop of the reagent, put a drop of the mixture on a porcelain dish, add a small drop of the confirmatory solution, and watch whether a yellowish-red color appears. As soon as it does, all the albumen is precipitated and the reaction is finished.

---

* This is the formula given by Stephen (London "Lancet," October 14, 1882, p. 614), and is the one used by us.

As the precipitating solution is so constituted that one drop from the five-centigramme pipette will precipitate five milligrammes of albumen, and it takes three drops to give the color reaction with the confirmatory solution, *the number of drops used, less three, multiplied by five, will give the number of milligrammes in* 10 *c.c.* of urine; or, more simply, each drop, after three have been subtracted, will represent a half gramme of albumen in a litre of urine. From this, of course, the twenty-four hour amount can be readily computed.

If this test be improperly performed, mucin, urates, urea, peptones, and vegetable alkaloids will be precipitated, as well as albumen. The two former may be eliminated as before mentioned. If sufficient acetic acid has been added, urea is not precipitated. Peptones and the vegetable alkaloids are dissolved by heat. Of the vegetable alkaloids, the only ones likely to be present in disturbing quantity are those of cinchona bark and opium. In view of these facts, however, no known quantitative test founded on the precipitability of albumen by this reagent can be chemically exact as applied to the urine.

Picric acid mainly owes its present popularity to Dr. George Johnson, of London,* who was unaware, when he published his first investigations, that Galippe had preceded him in its discovery as a test for albumen. This reagent is almost as delicate as potassio-mercuric iodide, and much more so than nitric acid. It is also non-corrosive, but will stain clothes and fingers, as microscopists are aware. It may be used in powder, or, better, in saturated solution (about one part acid to fifty parts distilled water). Some authorities (as Dr. Oliver) advise the addition of citric acid to the test solution; but, in our opinion, it is better to add the citric, or acetic, acid to the suspected fluid before adding the reagent, so that their effects can be differentiated. Dr. Johnson himself thinks the addition of another acid unnecessary. The best method of using this test is by overlaying the suspected fluid with the test solution (having previously acidulated, as in the foregoing test), which the specific gravity (1003) of the latter renders possible in most cases. This is best accomplished by adding gently from a pipette nearly an equal volume of test fluid to 10 c.c. of urine contained in a test tube which is slightly inclined. If albumen be present, a white flocculent precipitate will take place just above the zone of contact, contrasting distinctly with the bright yellow of the picric acid solution. This precipitate is soluble in excess of albuminous urine, but not of reagent. Mixture, not mere contact at the point of junction, of the two fluids is necessary to produce this reaction.

---

* He has contributed a series of papers to the London "Lancet" (beginning in 1882) regarding its use in urinary analysis.

This reagent is open to the same objections as the preceding, and has almost the same advantages. It precipitates mucin (Dr. Johnson to the contrary notwithstanding), urates (when present in excess), peptones, and vegetable alkaloids, as well as albumen. The two first may be eliminated as in the preceding test, and all of them dissolve on heating except mucin and albumen, so that all sources of error can easily be removed.

Sodium tungstate was brought before the profession by Dr. George Oliver,* and he recommends for the test solution equal parts of saturated solutions of sodium tungstate (one to four) and citric acid (ten to six). Owing to its specific gravity (1214) it is best used as nitric acid in Heller's method. It is very delicate, being about as sensitive as picric acid (according to Oliver, it will detect one part albumen in 20,000 water), and precipitates the same substances, with the exception of alkaloids. Heat also has the same effect on precipitates caused by it.

Potassium ferrocyanide is less delicate than the preceding three reagents, but more so than nitric acid. It is used in saturated solution, and requires previous acidulation of the urine. It does not precipitate mucin, peptone, or the alkaloids, but does throw down the urates.

Metaphosphoric acid, introduced by Hindenlang,† and the *brine test* of Roberts, have had their advocates; but there are serious objections to both. The first is a very sensitive reagent, but precipitates proteids and is not stable, for, on standing a short time, it becomes converted into orthophosphoric acid, which does not precipitate albumen. The brine test (saturated solution of common salt acidulated with one per cent. strong HCl) is not as delicate as either picric acid, sodium tungstate, or potassio-mercuric iodide, and precipitates proteids besides. On this account its author has discarded it in the last edition of his work.

---

* London "Lancet," Vol. I., 1883, p. 139 *et seq.*

† "Berlin. klin. Wochenschrift," 1881, No. 15.

While some authorities, noticeably Dr. Roberts, consider these new reagents of little clinical value, and rely simply upon nitric acid and heat for the detection of albumen, we can not agree with them. The precipitation of so many substances, usually of different clinical significance from that of albumen, is often misleading if we rely on any one test; yet a combination of two of them, as the potassium ferrocyanide and picric acid, or potassio-mercuric iodide, may give us valuable information not only in regard to albumen, but also in regard to other proteids. Besides which, with proper manipulation of any one of these tests with heat, we can eliminate sources of error, and even the nitric acid test (a less sensitive one) ought always to be supplemented by boiling, and sometimes by alcohol in addition. The negative value of the most delicate reagents is unquestionable, and any albumen undetected by them is certainly of no clinical significance. It is true that we have not yet worked up to the full pathological significance of the trace of albumen missed by nitric acid and heat and detected by other tests, but it may not be long before we do so, and even now we should be put on our guard against a more serious albuminuria. With our present knowledge we think it best to begin testing a suspected urine with one of the most delicate tests, and, if albumen or a proteid be indicated, apply heat and nitric acid certainly, and, better, some of the other proteid tests, of course supplementing all by the microscope before forming a diagnosis.

Dr. Oliver* has ingeniously contrived a series of "test papers" suitable for bedside testing, but not, in our opinion, as satisfactory as the solutions. They are arranged for sugar and albumen testing (the latter based on the recent delicate tests), and are for sale in London and in this country.†]

2. *Sugar.*

The urine-sugar, $C_6H_{12}O_6 + H_2O$ (identical with grape-sugar), is, according to Brücke, a constant constituent of normal urine. It is present in such exceedingly minute quantity, however, that when we use Trommer's test we do not observe the least precipitate of yellow cuprous hydrate. We observe that the mixture simply changes color. In pathological urine, especially in diabetes mellitus, we find so great an amount of sugar that the urine possesses a sweet taste; and if a piece of cloth is saturated with it, after the evaporation of the urine the cloth is as if smeared with honey.

[* See London "Lancet" for 1883, and "Bedside Urine-Testing," London, 1885.

† Parke, Davis & Co., New York and Chicago, prepare a very convenient case containing them, with directions for their use.]

The urine-sugar crystallizes in agglomerated masses, which resemble cauliflower in form.

Of the various tests for sugar, the following are generally employed:

1. *Heller's* or *Moore's Test.*—Pour into a test-tube two volumes of urine and one volume of KOH or NaOH, and heat to boiling. The earthy phosphates fall, and if present in great amount must be filtered off. As soon as the fluid becomes hot, a lemon-yellow, yellowish-brown, or blackish-brown color appears, according to the amount of sugar present. If we now treat this with a few drops of nitric acid, the dark color vanishes, and it gives off the smell of molasses. If albumen is present in great amount, it should be previously separated by boiling and filtering. If the urine has a dark color, which is seldom the case in diabetes, we must render it colorless by acetate of lead (by this means a slight amount of sugar falls), or by filtration through animal charcoal. This filter must be washed with water, for it contains much sugar.

If the urine has a dark color from the addition of KOH in the cold, it is generally due to the biliary coloring matter. This change of color takes place if the biliary coloring matters have already decomposed, i. e., if the urine does not give Gmelin's or Heller's test for the biliary matters. In this case the change of color, especially if by the addition of sulphuric acid a very dark color is produced, is a good proof of the presence of biliary coloring matters.

According to Bödecker, if a urine which has been treated with potassium hydrate (KOH) and allowed to stand in the air gradually colors brown from above downward by absorption of oxygen, it contains a peculiar substance which he calls alkapton. This body will reduce the copper salt, but not the bismuth salt. Probably this body is pyrocatechine.

[Dr. W. G. Smith * met with a case in which the urine (that of an apparently healthy child, three years old, and not taking medicine) gave the characteristic reactions of Bödecker's alkapton, i. e., strong alkalies darkened the urine without the application of heat, and the discoloration proceeded from the surface down (oxidation co-operating with the alkali); it partially reduced the copper test, and was unfermentable by yeast. This substance also quickly reduced silver nitrate and had a slight reaction with the Löwe bismuth test for sugar. Ferric chloride produced a distinct green color, turned to reddish-brown upon the addition of an alkali. The specimen contained no bile or albumen. From these and other reactions mentioned in Dr. Smith's article, he concluded that the substance in question was protocatechuic acid, a conclusion confirmed by Prof. Hartley's optical examination. It would seem, therefore, that "alkapton" is to be regarded as a general term.

M. Vetlesen † reports that, after the internal administration of turpentine, there appears in the urine, in rather large quantity, a substance fermentable slowly

---

[* Dublin "Journal of Medical Science," June, 1882, p. 465.

† Abstract in "Medical Times and Gazette," September 16, 1882, p. 364.]

by yeast, without dextro-rotatory power, which will reduce an alkaline solution of bismuth oxide on boiling, and also cupric oxide, and a small amount of hydrochloric acid will destroy it at a low temperature.]

Mulder's test gives a beautiful color reaction. If a colorless saccharine urine is heated with a solution of indigo-carmine, which has previously been made alkaline by sodium carbonate, the blue mixture becomes first green, then purple-red, and finally yellow. If we shake the heated mixture in the air it takes up oxygen, and the color again passes back to blue. If but a small amount of sugar is present, the indigo-carmine solution only becomes a pale blue.

[This test has been adopted by Dr. Oliver in his test paper series, and he claims for it sensitiveness equal to that of the picric acid or Fehling's test, and less liability to sources of error. He also claims approximate accuracy for his method as a quantitative test. We have had no opportunity of experimenting with the indigo-carmine papers prepared in London, but those of Parke, Davis & Co. have not been satisfactory in our hands; and, in our opinion, quantitative results obtained by the average practitioner from shades of color as delicate as those produced in this test are, to say the least, open to question. One wishing full details of this test will find them in the works of Drs. Oliver* and Tyson.†]

2. *Trommer's Test.*—Treat as before two volumes

[* "Bedside Urinary Testing," third edition, 1885.
† "Practical Examination of Urine," fifth edition.]

of urine with one volume of the KOH or NaOH solution (1 part in 3); add now drop by drop a solution of cupric sulphate (1 part to 10), shaking after each addition until the mixture shows a clear, beautiful azure-blue. Then heat over a spirit-lamp. If sugar is present, a reduction of the cupric oxide immediately takes place, and in the following order: First appears a yellow cuprous hydroxide, which soon loses its water and becomes the red cuprous oxide. If the urine contains albumen in large quantity, it must first be separated by coagulation. If we do not remove the albumen, it has a marked influence on the reaction, so that the mixture of urine, KOH and $CuSO_4$, does not become blue, but of a violet color. If neither sugar nor albumen is present, we obtain neither an azure-blue nor a violet-colored solution, but a turbid grayish-green fluid, and by application of heat there is naturally no reduction of the cupric salt.

It is better to employ a solution of sodium-potassium tartrate (Rochelle salt) in sodium hydrate (NaOH). If we add NaOH to the cupric sulphate solution, cupric hydrate ($Cu[OH]_2$) falls. If grape sugar is present, a corresponding amount to this will be held in solution. If we have added too much cupric sulphate, there is an excess of the precipitated $Cu(OH)_2$ in the solution, and the same must be filtered off, because it would otherwise change to the black oxide of copper (CuO), and thereby interfere with the reaction.

By the employment of the sodium and potassium tartrate solution we preserve a clear fluid.

A large amount of creatine, peptone, etc., may prevent the reduction to cuprous oxide.

[Roberts's test is practically the same as this, and is a modification of Fehling's test used qualitatively. He proceeds as follows: "Fill a test-tube to the depth of three quarters of an inch with the copper solution;* heat until it begins to boil, and then add a drop or so of the suspected urine. If it be ordinary diabetic urine, the mixture, after an interval of a few seconds, will turn *suddenly* an intense opaque-yellow color, and in a short time an abundant yellow or red sediment falls to the bottom. If, however, the quantity of sugar present be small, the suspected urine is added more freely, *but not beyond a volume equal to that of the test employed.* In this latter case the suboxide is always precipitated yellow,† never red.‡ The method of performing the test should be as follows: The copper solution having been heated to ebullition, and something less than an equal bulk of the suspected urine having been added, the mixture is again raised to the boiling point. It then changes to an intense opaque yellowish-green, and slowly a bright yellow deposit precipitates. If the urine contains less than a one half grain percentage of sugar, the precipitation does not take place immediately, but occurs as the liquid cools

---

[* *Op. cit.*, pp. 208–212.

† Fehling's fluid, see "Quantitative Determination," p. 216.

‡ C. Giacomo ("Chem. Centralblatt," 1884, p. 185) finds that creatinine will cause the *yellow* discoloration sometimes seen in testing with Fehling's fluid, obscuring the presence of a trace of sugar, and necessitating the presence of more copper than would be reduced by the sugar alone.]

in five, ten, or twenty minutes, and the manner of the change is peculiar. First, the mixture loses its transparency, and passes from a clear olive-green to a light greenish opacity, looking as if several drops of milk had fallen into the tube. This green milky appearance is quite characteristic of sugar. By this proceeding, one tenth of a grain per fluidounce, or less than one fortieth of a grain per cent., can with certainty be detected, and any quantity below this has no pathological signification, and is a matter of only physiological interest."

He especially cautions against prolonged boiling in such cases, as it, and *only it*, causes the mixture to assume "a muddy, dirty fawn appearance," with reddish deposit, although no sugar be present. The reddish deposit he considers due to the precipitated phosphates colored red by some suboxide, "reduced, perhaps, through the instrumentality of uric acid." He claims, however, that if his method be properly used, uric acid and the urates will not be a source of error.]

3. *Böttger's Test.*—Treat as above two volumes of urine with one volume of KOH, and add as much as can be taken up on the point of a penknife of magistery of bismuth (a mixture of basic bismuth nitrate, $BiO.NO_3 + H_2O$, and some bismuth nitrate, $Bi(NO_3)_3 + 5H_2O$), and heat for a short time over a flame. Sugar reduces the bismuth salts, so that black suboxide of bismuth (Bi_2O_2) is formed. If only a little sugar is present, the white bismuth powder is colored light gray, because simply a part is reduced. If but a trace

of sugar be present, then an excess of the bismuth nitrate may conceal the reaction.

If albumen is present, this must first be separated, for by the decomposition of the albumen a black sulphide of bismuth is formed, which may be easily mistaken for bismuth suboxide. In order to ascertain to what the color is due, we take a sample of the urine made alkaline, and add to it a few drops of lead acetate, and boil. A black precipitate indicates the presence of a sulphur compound in the urine.

Brücke recommends for the separation of disturbing elements Frohn's reagent.* Take equal quantities of water and urine in two test-tubes; to the first add HCl until a drop of the reagent no longer produces cloudiness. In this way we ascertain approximately how much HCl must be added to the urine. After acidification we treat the urine with the reagent and filter (the filtrate should then not become cloudy by the addition of HCl or the reagent). Add now an excess of NaOH. Should the precipitate of bismuth hydrate be too copious, a little should be removed by decantation; then we heat a long time, as with Böttger's test.

Maschke gives the following modification: Treat the urine with one third its volume of tungstate solution.† If proteine substances are at hand, there arises a precipitate. After the settling of the same, add a few drops more of the reagent to see if all the proteids have come down. To the filtrate add half the volume of concentrated NaOH and a small amount (as much as half a pepper-grain) of basic bismuth nitrate, and shake well. If this is not colored brown or black, we must boil for some time and observe after cooling whether a black precipitate has formed. If the precipitate of bismuth is already black before the boiling point is reached, we may decide on the presence of diabetic sugar; a slight browning, or later becoming black, shows only the normal amount of sugar present. If the bismuth oxide becomes brown before warming, there is a sulphide in solution. We must in this case take a new sample of urine, weakly acidify with acetic acid, shake up well with some bismuth nitrate, and treat the filtrate as above directed.

---

* Frohn's reagent (iodide of bismuth and potassium): 1·5 grm. of unwashed freshly precipitated basic bismuth nitrate is mixed with 20 grms. of water and heated to boiling; then 7 grms. of potassium iodide, and finally 20 drops of HCl are added. The resulting fluid is orange-red.

† Crystallized tungstate of sodium, 30 parts; acetic acid (30 per cent.), 75 parts; water, 120 parts.

[In this connection picric acid deserves mention as a delicate reagent for the detection of glucose. The basis of its use as a test is the fact that when solutions of grape sugar and picric acid are boiled together in the presence of caustic potash, the yellow picric is reduced to the deep red picramic acid. This was discovered by C. D. Braun some twenty years ago, but was not much utilized until Dr. George Johnson, of London,* having accidentally stumbled upon the same fact, strongly advocated its application to the examina-

---

[* British "Medical Journal," March 17, 1883, and series of communications to the "Lancet," beginning November 18, 1882.]

Aqua Sterilized ℥ss – Ft Solution
Glycerine ℥ss – mix
Liquor Potassæ ad ℥ V

tion of diabetic urine. The test is both qualitative and quantitative, and for its performance by Johnson's method are necessary:

1. A cold saturated solution of picric acid.
2. Liquor potassæ (specific gravity, 1058).
3. A standard color solution.

The last is prepared as follows:

Take a fluidrachm of a solution of grape sugar in the proportion of a grain to the fluidounce (of distilled water), mix it with half a fluidrachm of the liquor potassæ and ten minims of the saturated picric-acid solution, and make up the mixture to four drachms with distilled water. Heat this mixture to the boiling point, and continue boiling sixty seconds by the watch, so as to insure complete reaction between the sugar and the picric acid. During the process of boiling, the color of the liquid is changed to a beautiful claret-red. The liquid is then cooled by careful immersion of the test-tube in water, and it having been ascertained that there are four fluidrachms of the mixture, or, if there are not, enough distilled water to make up the four drachms having been added, the color of the mixture is that which results from the decomposition of the picric acid by one eighth of a grain of sugar (i. e., sugar in the proportion of a grain to the ounce), and is a convenient standard for comparison in volumetric analysis.

The color thus obtained is not, however, permanent. As a permanent solution of exactly the same shade, Johnson recommends:

Liq. ferri perchlor. fort. (B. P.)	fʒj,	
Liq. ammon. acetat.	fʒiv,	
Acid. acet. glacial.	fʒiv,	
Aq. destillat.	ad f℥ijss.	M.

It is a good precaution, before using this, to compare it with some freshly prepared glucose standard solution. To perform the test: Take one drachm of the suspected urine, half a drachm of the liquor potassæ, ten minims of the picric-acid solution, and enough distilled water to make four drachms; raise the temperature of the mixture to the boiling point, and continue boiling for sixty seconds. If the prolonged boiling has diminished the volume of the mixture, bring it to four drachms again by the addition of distilled water, and compare its color with that of the standard solution. It is hardly necessary to state that in this comparison vessels of the same shape and size should be used, and they should be viewed by transmitted light.

If the color of the mixture is darker than that of the solution, sugar in abnormal quantity is present. To determine the exact amount, distilled water should be added until the mixture is of precisely the same shade as the standard solution. The amount of water added should be noted, because the number of volumes of water added, plus one (the volume of the mixture), give the number of grains of sugar per ounce in the urine. For example, if to one drachm of the mixture it has been necessary to add two and a half volumes of water, $1 + 2\frac{1}{2} = 3\frac{1}{2}$ is the number of grains per ounce.

Inasmuch as ten minims of the picric-acid solution only a little more than suffice for the reaction of one eighth grain of sugar, a larger proportion of sugar than one grain to the ounce would require for its reducing action more than ten minims of the picric-acid solution, and, in order to determine whether or not sugar is present in such proportion, repeated trials with twenty, thirty, forty or more minims of the picric-acid solution must be made until the last two trials show the same shade of color. If sugar is present in greater amount than six grains to the ounce, before making the final analysis the urine should be diluted with one or more volumes of distilled water, and the resulting mixture tested as above. An excess of picric acid will not materially affect the test, but the same amount of liquor potassæ must always be used.

If the first trial with ten minims shows a lighter color than the standard, sugar in less quantity than one grain to the ounce is present, which is of slight clinical importance. In case it be desired to find the exact amount, the standard solution should be diluted with an equal volume of distilled water (making the color that given by 0·5 gr. sugar to the ounce), and the test proceeded with as before.

From an examination of several hundred specimens of apparently normal urine, Johnson has found that there exists in normal urine a substance (or substances) which is not decomposed by prolonged boiling, is unfermentable by yeast, and which equally with glucose reduces picric acid and cupric oxide. He regards this substance as "saccharoid," and finds it present in the proportion of 0·5 to 0·7 gr. per ounce (average 0·6 gr.) in all normal urines. This "saccharoid" substance has been proved to be creatinine. The mere boiling together of picric acid and a solution of caustic potash will cause an orange-red coloration (due to the formation of potassium picrate). This need not, however, be a source of error; but the presence of alkali sulphides in the urine will reduce the picric acid, although Johnson claims that the presence of albumen does not affect the test. Oliver states that inosite, creatine, and creatinine will reduce the acid; these and other reducing agents sometimes found in urine are only likely to cause error in case of very slight glycosuria. The simplicity of the method, and the use of the acid as a test for albumen, commend its use to the busy practitioner for approximative testing in *decided cases of glycosuria.* We can (from examination of diabetic urines and artificial solutions of glucose in water and urine) confirm Dr. Johnson's statement that its quantitative results are almost identical with those by Fehling's test when glucose is present in larger quantity than one grain to the ounce.]

Heller's test is the simplest and best, and has besides the advantage that one can form an approximative determination in regard to the amount of sugar present from the intensity of the color. In the second rank comes the bismuth test, for if the urine is free from albumen there is no other substance present which can reduce bismuth. As to Trommer's test, it is least to be recommended because, besides sugar, there are in urine other bodies which if present in quantity may reduce the copper salt. Such are especially uric acid, hippuric acid, and the urates. There are many known cases, as in febrile processes, in which large quantities of urates are present in the urine, where sugar might erroneously be supposed to exist, if we relied simply on the yellow color of the mixture, without the reduction of the oxide having been observed. The most reliable tests for all cases are the fermentation and the polarization tests, but these are generally inconvenient for the practicing physician.

[Dr. Roberts has devised a method by which the fermentation test can be made very useful to practitioners, provided sugar be present in more than 0·5 per cent., or 2½ gr. to the ounce. He has found by repeated experiments (and his results have been practically confirmed) that each degree difference (measured on the urinometer) of specific gravity between fermented and unfermented samples of the same saccharine urine at the ordinary temperature (59°–77° Fahr., 15°–25° C.) represents one grain of sugar to the fluid-ounce; or, multiplied by the co-efficient 0·23, will give the percentage of sugar present. The test is best made by taking two samples of the same urine (say 100 c.c. each), and to one in a bottle with a nicked cork (to allow the generated carbonic-acid gas to escape) add a lump of fresh German yeast (about the size of a small walnut); put the other in a tightly-stoppered bottle, and place the two bottles side by side in a warm place.

After twenty-four hours take the specific gravity of the two specimens (at the ordinary temperature), and the difference between them will represent the number of grains of sugar per fluidounce as above mentioned.]

If it is granted that sugar is present in the urine of a patient, it is quite important to know how much is present and how much is excreted in twenty-four hours. The most accurate quantitative methods are spoken of later. We may form an approximative conclusion from the specific gravity. The higher the specific gravity the more sugar should be present. This is true for a simple sugar solution, but not for such a compound fluid as is the urine. Bence Jones has shown that this method is not always to be relied upon, even for an approximative test.

The second method is that of Vogel, which consists in determining, from the more or less intense color produced by the KOH test, the amount of sugar present. This is quite convenient for the physician. If one prepares for himself solutions of grape sugar of different strengths, and makes the tests with KOH in tubes of the same size, he can easily form a scale of the percentage of sugar present which will be fairly satisfactory. Treat two parts of each sugar solution with one part of KOH, and heat to boiling. A one per cent. solution will be colored canary-yellow; a two per cent. solution, dark amber; a five per cent. solution, the color of dark Jamaica rum; and a ten per cent. solution becomes dark brown and opaque, while all solutions of less percentage are more or less transparent. As the diabetic urine has a very light color, so by comparison with these solutions an approximative determination can be easily arrived at, with the help of the known specific gravity.

Sugar in large amount occurs in only one group of diseases, namely, glycosuria. A temporary glycosuria occurs after many lesions of the brain, and also a small amount in acute febrile processes, after spontaneous gangrene, pneumonia, typhus, rheumatism, and acute encephalitis; in affections of the nervous system, especially of the spinal cord; in cachexies and similar processes; also after the introduction of turpentine, nitrobenzole, nitrite of amyl, etc.

Neukomm and Vohl have exceptionally found inosite in diabetic urine, either with or in place of grape sugar. Also in acute Bright's disease inosite has been found in the urine.

[This substance (also called muscle sugar) has been found in muscle, lungs, spleen, liver, kidneys, and brain; and, in addition to the before-mentioned diseases, it has also been detected in cases of phthisis, syphilitic cachexia, typhus, and disease of the medulla, also in two cases of tumor in the vicinity of the fourth ventricle; although in a case of polyuria, with inflammation of the fourth ventricle, Pribram (as quoted by Belfield, "Diseases of the Urinary Organs," p. 128) was unable to detect either glucose or inosite. In several cases of inosituria, without any tangible disease, Ralfe observed moderate but not excessive polyuria, general malaise, and always considerable aching of the limbs. The full pathology of this disease (if it may be called such) is as yet but little known.

Inosite crystallizes in large rhombic tables or transparent, colorless prisms, is not fermentable by yeast, but is capable of lactic-acid fermentation, and in aqueous solution is optically indifferent. A solution of inosite evaporated with nitric acid almost to dryness, the residue being moistened with a little ammonia and chloride of calcium, and again evaporated carefully to dryness, will yield a vivid rose-red color, which is apparent with one milligramme of inosite (Scherer). According to Cloretta, Ralfe, and Oliver, it is inosite which causes the green color (followed by a light greenish precipitate and return of blue color to the supernatant fluid) sometimes observed in using Fehling's test. Reboiling this precipitate will cause the same change of color. For further details, see Neubauer and Vogel, edition 1881.]

The breath of many diabetics has an odor like chloroform. Their fresh urine has the same smell after standing a short time. It is colored dark reddish-brown with iron chloride. In the distillate of such urine, acetone and alcohol are found, which may arise from the breaking up of ethyl diacetate:

$$\underset{\text{Ethyl diacetate.}}{C_6H_{10}O_3} + 2H_2O = \underset{\text{Acetone.}}{C_3H_6O} + \underset{\text{Alcohol.}}{C_2H_6O} + CO_2 + H_2O.$$

[Lactose occurs in crystalline form (right rhombic prisms terminated by octahedral points), is not very soluble in water (1 part to 6 cold water), and precipitates alkaline copper solutions and indigo-carmine. It does not undergo the alcoholic fermentation easily with yeast, but readily undergoes the lactic fermentation, and has a dextro-rotatory power of 59·3°.]

In women, milk sugar (lactose) appears in the urine from twenty-four to forty-eight hours after the weaning of children, or as soon as from any cause the milk is not sufficiently gotten rid of (lactosuria).

[Lævulose (obtained from invert or fruit sugar) has been occasionally observed in the urine of persons having the symptoms of diabetes, with or without glucose. It reduces cupric-sulphate solutions as glucose, but may be distinguished from the latter by its left-handed polarization, care, of course, being taken to exclude other lævo-rotatory substances. Its power of polarization diminishes with elevation of temperature, being 106° at 14° C., 79·5° at 52° C., and 53° at 90° C. Its clinical significance is unknown.

Of late the occurrence and pathological significance of acetonuria and diaceturia have attracted a good deal of attention, and von Jaksch * has done much to advance our knowledge of the subject, which is still, however, rather obscure. He believes that the volatile substance which Lieben says is contained in the distillate from normal urines, and from which iodoform is obtained by the action of sodic or potassic hydrate and iodine, is acetone, and is therefore to be considered a

---

[* "Bericht der deutsch. chem. Gesellschaft," 1882, p. 1492, and in other publications more recently. See especially a summary of his views by Dr. P. C. Griffith ("Philadelphia Medical News," October 3, 1885).]

constant and normal product of tissue metamorphosis. He has also obtained a slight iodoform reaction from the blood of living and dead persons. The amount in the urine of a person in health is, however, probably not more than 0·010 grm. This may be increased in diabetes mellitus, hydrophobia, carcinoma, and the so-called "*acetonæmia.*" It is found in relatively large quantities in the distillate from febrile urine, as a rule several decigrams; and the degree rather than the kind of fever influences the amount. The best method to detect it is probably Lieben's: To a portion of the distillate of urine add a small quantity of liquor potassæ, and then a few drops of a solution of iodine and potassium iodide. A yellow precipitate will at once occur if acetone be present. The presence of alcohol will delay the formation of the precipitate.*

Jaksch has also found that the substance in many urines which gives the Bordeaux-red with ferric chloride,† and which on warming gives acetone, is diacetic acid, and that its occurrence in the urine in disease is a very serious complication. It has been noticed in mental diseases with excitement, with inanition and carcinoma, and especially in diabetes mellitus, although there seems to be no relation between the amount of sugar and diacetic acid eliminated. Sometimes a sud-

---

[* Baginsky found acetone in normal urine of children, and regards its presence as intimately connected with protein waste.

† According to Le Nobil, formic acid, often present in diabetic urine, gives a similar reaction with ferric chloride ("American Journal of Medical Sciences," vol. xciii, p. 239).]

den diminution of glycosuria is succeeded by an increase in the amount of diacetic acid in the urine, coma, and death. He considers what is usually known as diabetic coma to be due to the presence in the blood not of acetone, but diacetic acid, and he proposes to substitute "coma diaceticum" for "diabetic coma" in all cases accompanied by diaceturia. It is not to be forgotten, however, that diabetic coma sometimes occurs without either acetonuria or diaceturia.

His method of detecting diacetic acid is this: Take a freshly voided sample of urine, and to a small portion add a few drops of a solution of ferric chloride. If the phosphates are precipitated, filter them off, and to the filtrate add a few more drops of ferric-chloride solution. If a red color is produced, boil a portion of the urine, and to another portion add a few drops of sulphuric acid, and shake up with ether. If the red color appears but slightly, or not at all, in the boiled portion, and grows pale after twenty-four hours in the ethereal extract, and, furthermore, acetone is detected in considerable quantity in the distillate, we have to do with diacetic acid.

As opposed to Jaksch's results, however, Frerichs * found that the introduction of acetone and aceto-acetic acid into the bodies of animals was followed by no bad effects, and that considerable quantities had to be given before the urine reacted for acetone; and K. Albertoni † very recently states that he finds acetone is not

---

[* "Zeit. für klin. Med.," Bd. VII., Suppl., 1883.

† Quoted in "Boston Medical and Surgical Journal," October 15, 1885, from "Journal of Chemical Society of London," June, 1885.]

injurious, and even in large doses only produces intoxication. When given to healthy persons in doses larger than 3 c.c., it passes unchanged in the urine. Ethyl aceto-acetate, or aceto-acetic acid, produces nothing like diabetic coma, but sometimes causes the urine to become albuminous. Oxybutyric acid, a lævagyrate body which reduces copper salts, is considered by some to be the real cause of diabetic coma. They claim it has been frequently mistaken for diacetic acid in diabetic urine.]

3. *Leucine and Tyrosine.*

Leucine ($C_6H_{13}NO_2$) and tyrosine ($C_9H_{11}NO_3$) are the decomposition products of the albuminous bodies and their derivatives. We find both these substances in several glandular organs of the body, especially if they have been subjected to certain pathological changes; for instance, in the liver, pancreas, and spleen. In urine these substances have as yet been noticed in any great quantity only in acute atrophy of the liver and in a few cases of phosphorus-poisoning. Small quantities are observed in typhus and small-pox.

If these substances are present in great quantity in the urine (as is generally the case in acute atrophy of the liver), the proof of this is very easy. We either find the crystalline tyrosine already in the sediment, or it separates together with the leucine if we evaporate the urine on a water-bath to a small bulk. Sometimes both bodies are found in such large amount in the urine that they almost supplant the urea. They are easily recognized microscopically from the evaporated urine by the characteristic form of their crystals. (Pl. IV., A.)

If these substances are not present in so large quantity that they separate by simple evaporation of the urine, then we take a great bulk of the latter. If rich in bile pigments and albumen, the urine is treated with a solution of basic acetate of lead, filtered, and the filtrate treated with hydrogen sulphide to remove the excess of lead, filtered again, and the clear filtrate evaporated on a water-bath to small bulk. If tyrosine is present, it crystallizes beautifully after standing twenty-four hours. Leucine, which is much more soluble than tyrosine, appears much later. The urine must be as fresh as possible to work upon.

The presence of leucine and tyrosine in large amount indicates a considerable destruction of the proteine substances. Albumen for the most part accompanies them. Often oxymandelic acid ($C_8 H_8 O_4$) also occurs—a substance nowhere else observed, and which is perhaps a derivative of tyrosine.

4. *Abnormal Coloring Matters.*

Among the abnormal coloring matters, we are to distinguish between those which occur normally in other fluids of the body, as the blood- and bile-coloring matters, and those which are only found in the urine, as uroërythrine, and plant-coloring matters accidentally excreted by the same.

a. Uroërythrine (*Harley's urohæmatine*). In all febrile diseases the urine has a more or less dark reddish-yellow color (*urina flammea*), and an expert is able to diagnose in most cases a febrile state from the urine alone. This color arises, according to Heller, from uroërythrine (as well as from an increase of the normal coloring matters). If on cooling a deposit of urates occurs, they are mostly rose-colored to dark red. On addition of lead acetate to clear urine, the precipitate appears flesh-colored or rose-red. Heller calls this red coloring matter of the urine, which colors the brick-dust sediment and is also found in solution, uroërythrine.

This coloring matter should contain iron, but its constitution and mode of origin are unknown. It is possible that in febrile processes, especially such as are accompanied by blood-dissolution (typhus, septic fever, etc.), a part of the blood-corpuscles by their retrograde metamorphosis furnish the material for the formation of the uroërythrine.

The uroërythrine may be regarded as an indication of the breaking down of the blood-corpuscles in febrile processes.

Uroërythrine is recognized when present by the color of the brick-dust sediment, or, if no sediment be present, by the color of the solution, in which if treated with acetate-of-lead solution a rose-red or flesh-colored precipitate falls. Only a little of the lead solution should be added, so that the coloring matter shall not be disguised by too much of the precipitate. If the urine contains the blood-coloring matters, these must be first separated.

The foam of a urine containing much uroërythrine may be yellow as in icterus; but with the latter the precipitate from the lead salt is also yellow.

The earthy phosphates which are thrown down by heating the urine with KOH appear gray, while if the urine contains blood-coloring matters they are blood-red or dichroic. The absence of albumen in the urine, the gray color of the earthy phosphates, and the red precipitate from lead salt, serve as points for the differential diagnosis between uroërythrine and blood-coloring matters.

Uroërythrine occurs in all febrile conditions, even in the lightest catarrh, but most abundantly in pyæmia, liver affections, and lead colic.

β. The Vegetable-coloring Matters.—Many vegetable-coloring matters, especially chrysophanic acid (in rhubarb and senna leaves), impart to alkaline urine a reddish-yellow to deep red-color. These are easily recognized from the fact that on the addition of an acid the urine loses its color, which returns again upon addition of an excess of ammonia. After heating with KOH, if a precipitate of earthy phosphate falls, it is often colored blood-red, so that one might be induced to believe there was blood-coloring matter in the urine. The precipitate never appears dichroic, but by long exposure to the air becomes violet.*

The fact that the urine loses its color by addition

[* Santonin also imparts a bright yellow or greenish-yellow color to urine, which might induce one to think bile-coloring matters present; but the addition of ammonia imparts a red or purplish-red color in the former case. A similar reaction occurs with madder, gamboge, and logwood.]

of an acid, and regains the red color upon addition of an excess of ammonia, and that it contains no albumen, distinguishes this reaction from that of the blood-coloring matters and uroërythrine. It is of importance for the physician to know this reaction, especially in summer, when the urine is apt to have an alkaline reaction and the blood-red appearance to cause alarm.

γ. *Blood-coloring Matters.*—The appearance of blood-coloring matters in the urine may be from a double origin. They may have been excreted by the kidneys, or may have arisen from the breaking down of blood-corpuscles in the urine. The color of this urine is different according as hæmoglobine or methæmoglobine is present in the urine.

From hæmorrhage of the large vessels the urine contains mostly hæmoglobine. By parenchymatous or capillary hæmorrhage the urine almost always contains some methæmoglobine, which imparts to the fluid a brownish-red color. The reason that at one time hæmoglobine alone, and at another with methæmoglobine also, appears in the urine, may be due to the fact that with capillary hæmorrhages, which occur in various kidney affections, the blood becomes more slowly and intimately mixed with the urine, and is held longer in solution at the normal temperature of the body in the organism. The temperature and carbonic acid of the urine, as well as the lack of oxygen, furnish the essential conditions for the change of hæmoglobine to methæmoglobine.

In order to prove the presence of the blood-coloring matters in the urine, the hæmine test is useful. The earthy phosphates are precipitated in a test-tube by adding KOH with slight warming. The earthy phosphates carry the blood-color substances to the bottom of the tube, and consequently do not appear white as in normal urine, but blood-red. If but a slight amount of blood-coloring matters is present in the urine, the precipitate will appear dichroic.

If an alkaline urine is evacuated, and by heating with KOH no earthy phosphates are separated, from the fact that they have been already deposited, we may by addition of a few drops of the magnesium solution form an artificial precipitate in the KOH mixture, which will by warming bring down along with it the blood-color substances just as well as do the earthy phosphates.

The precipitate containing the coloring matters of the blood should be filtered off and placed upon an object-glass, and warmed carefully until the phosphates are perfectly dry. Then the hæmine crystals can immediately be separated. For this purpose a few grains of common salt (Na Cl) are rubbed into the dried earthy phosphates containing the coloring matters; the excess of salt is then blown off the object-glass, and a hair is laid across the residue. A glass cover is laid on, a drop of glacial acetic acid added, and the slide warmed until little bubbles begin to show themselves under the glass cover. After cooling, crystals of hæmine can be seen under the microscope. Extreme care must be taken in this test, upon addition of KOH to the urine, to warm but slightly and filter rapidly, to avoid further decomposition of the blood-coloring matter. When the glacial acetic acid is added, gas bubbles form before heating, which are simply carbonic-acid gas. These are allowed to pass away, and then we heat to the bubble formation spoken of above, i. e., to the boiling point of acetic acid. The hæmine crystals obtained in this way often appear small and imperfectly crystallized, but with a high objective they are easily recognized. (Pl. V., A, 1, and Hofmann, l. c., 295.)

This can be done in another way as follows: Render the urine alkaline with NaOH, add tannic-acid solution, and then acetic acid. The washed and dried precipitate is treated for hæmine.

For the proof of blood-coloring matters in urine, separate the albumen by heat and coagulation, collect the brown coagulum on a filter, dry, and extract with alcohol containing some sulphuric acid. Permit the alcohol to evaporate. From the residue Teichmann's crystals of hæmine may be separated as above described. (See Appendix D.)

If a spectroscope is at hand, it is very satisfactory for the proof of the blood-coloring matters. The urine should be diluted and put into a large test-tube, and held between the slit and a petroleum lamp. ("Spectralbild des Methæmoglobin," K. B. Hofmann, l. c., 277, erste Abbildung, Nr. II.)

The so-called hæmatinuria (the passage of blood-coloring matters into the urine) occurs with constitutional diseases, such as scurvy, purpura, scarlatina, etc.

It is hardly necessary to add that after transfusion of blood, after inhalation of hydrogen arsenide, and also with true hæmaturia, soluble blood-coloring matters are mixed with the urine.

[Melanin has been met with in the urine of persons suffering from melanotic tumors and after repeated attacks of ague. Melanin deposits in the urine in minute lumpy granules, which are soluble in liquor potassæ and its alkaline solution, is decolorized by passing a stream of chlorine through it. Its solubility in liquor potassæ distinguishes it (Ralfe) from carbon granules, coal dust, or soot, sometimes accidentally mixed with urine.]

δ. *Biliary-coloring Matters.*—Under certain conditions the coloring matters of the bile may be mixed with the urine. The urine more frequently contains biliprasine than bilirubine, but not seldom other oxidation products. If unchanged bilirubine is present in the urine, by a simple test we obtain a beautifully characteristic color-reaction. If biliprasine is present, by the same test we only have a green color. If the biliary-coloring matters are further changed, the test entirely fails.

1. *Gmelin's Test.*—Into a small test-beaker containing the icteric urine we pour a sub-layer (in the same manner as we perform the test for albumen, by pouring the acid slowly down the side of the glass) of strong nitric acid, containing a little yellow fuming nitric acid ($HNO_3 + NO_2$). In the zone between the fluids there occur from below upward the colors green, blue, violet,

red, and yellow. The green is predominant, whereas the blue often does not appear. This test can also be made by adding weaker HNO_3 to the urine in a beaker, and then pouring under this mixture a layer of concentrated H_2SO_4.

2. *Heller's Test.*—Pour into a small beaker-glass about 6 c.c. of pure HCl, and drop the urine into it until the acid is distinctly colored. Stir this, and beneath the mixture pour a layer of pure HNO_3. In the intermediate zone there occurs a beautiful iridescence. If we now stir with a glass rod, the entire mixture shows the color-changes successively in the same order as they had been previously observed between the fluids. This may best be seen by transmitted light. This test is very delicate, easily applicable, and suffices for most cases of urinary investigation.

To detect the presence of but a small quantity of biliary coloring matters, 100 c.c. of urine must be gently agitated with 10 c.c. of chloroform in a flask, until the chloroform is colored yellow. Strong shaking is to be avoided, so that the chloroform will not break up into small drops, which will not again resolve themselves into a clear fluid. By closing the tube with the thumb and inverting the flask, it is easy to pour off about 1 c.c. of the colored chloroform into a test-tube containing 10 c.c. of pure HCl, when the yellow chloroform drops will sink as a colorless fluid to the bottom. If now with slight movement we add a little HNO_3, the chloroform at the bottom of the fluid will go through all the spectral color-changes which are shown in Gmelin's test.

For the reason that the changes take place very slowly, and because acids work but slowly upon biliary coloring matters dissolved in chloroform, this reaction is especially good for demonstrating the biliary color scale.

In all reactions upon the unchanged coloring matters of the bile, the green color is characteristic. If this is not recognized, we can not be sure concerning the presence of these coloring matters. Urine rich in indican gives also with Heller's test a play of blue, violet, and dirty reddish-yellow. The characteristic green of the bile matters is, however, not perceived when only indican is present.

If we test for albumen by pouring under the urine a layer of HNO_3 in a wine-glass, we see, when the unchanged bile-coloring matters are present, a green band between the fluids. If albumen also is present, its zone is colored green from the biliary coloring matters. Urine rich in indican may mislead as to the biliary color-reaction. There appears in the same position between the fluids an indigo-blue color, which in reflected light may be easily mistaken for green. In such doubtful cases the biliary matters are to be isolated, as before mentioned, by chloroform and proved by Heller's test; or the urine may be treated with lead solution, and the filtrate tested for indican.

3. *Ultzmann's Test.*—This test simply shows the characteristic green color with distinctness and certainty. We add to 10 c.c. of urine 3 or 4 c.c. of a pure KOH solution (1 part of caustic potash to 3 of water is essential), then shake and add an excess of pure HCl.

The mixture now assumes a beautiful emerald-green color.*

In icteric urine the precipitated earthy phosphates are colored brown by the biliary coloring matters.

The presence of altered biliary coloring matters (bilifuscine), i. e., such as no longer give the reactions of Gmelin's and Heller's tests, may be ascertained as follows: A clean white linen cloth (or filter-paper) is dipped into the urine and allowed to dry; the linen appears colored brown. The presence in the urine of altered biliary coloring matter causes also a very dark H_2SO_4 reaction: the urine does not appear garnet-red, but almost black. A similar reaction occurs in the presence of sugar and blood-coloring matters.

Finally, if the urine is warmed with KOH and the earthy phosphates fall, the urine is colored much darker than before the heating, and the precipitate of phosphates is colored brown.

Biliary coloring matters are found in the urine in various pathological processes of the liver, whether or not there exists an icteric coloring of the skin. Thus icterus can be prognosed one or more days in advance by the appearance of the urine. Further, these coloring matters are always present in phosphorus-poisoning.

[M. Neucki and N. Lieber † have observed a new

[* *Marechalt's Test* depends upon the production of an emerald-green color when to an icteric urine are carefully added a few drops of tincture of iodine, or a solution of bromine may be used instead of iodine (Laache, "Harn-Analyse," p. 126).

† "Jour. für praktische Chemie," 1882, Nos. 17, 18.]

coloring matter, which they propose to name uro-rosein. They first obtained it from a patient suffering from a severe form of diabetes mellitus, but afterward failed to find it in four other cases of the same disease, but have met with it in about ten per cent. of all pathological urines examined by them. They consider the reddish color produced by the addition of 5–10 c.c. of a twenty-five per cent. solution of sulphuric or hydrochloric acid to 50–100 c.c. urine as indicative of its presence. The substance seems to exist in the form of a sulpho-acid, and to resemble the rosaniline colors. Its other chemical properties and its spectroscopic appearance are detailed in their article.

Neusser * has observed, in a case of chronic pleurisy, a substance which he regards as hæmatoporphyrin, or a body nearly akin to it. The urine was blood-red in color, acid in reaction, and contained no albumen. The chemical reaction and spectroscopic appearance are given in the article.

P. Plósz thinks he has detected, in the urine of a case each of cysto-pyelitis with parenchymatous nephritis and chronic peritonitis with effusion, a substance, perhaps identical with the scatol derivative, which Brieger found in the urine of rabbits. The peculiarity of the urine was that, on exposure to the air, it became greenish-brown from the surface downward, and this coloration disappeared on exclusion of the air. When the urine was exposed in thin layers to the air it took

---

[* Abstract in "Zeitschrift für analyt. Chemie," 1882, p. 476.]

on a reddish color, which was constant. For other particulars regarding it, see Plósz article ("Zeitschrift für phys. Chemie," Vol. VI., pp. 504–507).]

5. *The Bile Acids.*

The bile acids appear very seldom in the urine, and when found exist in extremely small quantity. In icterus they are rarely found, although the biliary coloring matters are present in large amount. In parenchymatous affections of the liver, on the contrary, which are followed by a rapid destruction of that organ, the bile acids are undoubtedly present, but in very small amount even then.

It must be accepted that in these cases so much of the bile acids are formed that, the blood being unable to assimilate them, some are excreted unchanged.

Sometimes it happens that we are able to prove the presence of the bile acids by Strassburgers' method, as follows: Dissolve some cane sugar in the urine to be tested, dip in a piece of filter paper, and permit it to dry. If now we touch the paper with a glass rod dipped in H_2SO_4 (free from HNO_3), we perceive a purple-violet stripe (a red or reddish brown color is not decisive).

Usually the bile acids must be isolated from a great amount of urine and proved by Pettenkofer's test. The method of procedure is very complicated. About 500 c.c. of urine are evaporated on a water-bath to dryness, and the residue extracted with alcohol. This solution is again evaporated, and the residue again taken up with absolute alcohol. The alcoholic solution is again evaporated, and the residue dissolved in a little water, and treated with lead-acetate solution, avoiding an excess; the precipitate is collected, washed, and dried on filter paper. The biliary lead salts are then extracted with boiling alcohol. The solution after treating with carbonate of sodium is evaporated, and the sodium biliary salts thus formed extracted with absolute alcohol. This is now evaporated, and to the very highly concentrated aqueous solution of the residue we apply Pettenkofer's test, which depends upon the fact that when the watery solution of all biliary acids is treated with a few drops of a concentrated cane-sugar solution, and after that with a few drops of concentrated H_2SO_4, the solution is colored purple-violet, if we take care that the mixture is not heated above 50° C. It is a good plan to place the dish or test-tube in cold water before the addition of the H_2SO_4; for otherwise the sugar may be carbonized by the H_2SO_4 and a blackish-brown solution ensues.

The merest trace of these acids may be discovered by Neubauer's modification of this. A few drops of the solution to be analyzed are evaporated to dryness in a porcelain dish over a water-bath. Add now a drop of a cane-sugar solution (1 grm. sugar to 500 c.c. water), and as much concentrated H_2SO_4; warm them on a water-bath until the edge shows a violet color, then remove, and the reaction goes on.

A large number of other substances, as amyl, alcohol, albumen, and oleic acid, give similar reactions. The spectroscope shows, however, an essential difference. (S. Hofmann, l. c., 195.)

[The practitioner who has had much experience with our present methods of testing for bile acids will, no doubt, welcome a more simple and satisfactory test for their presence. Such a one seems to have been devised by Dr. George Oliver.* To detect the presence of these substances, he utilizes the physiological fact that the products of gastric digestion (peptone and propeptone) are precipitated along the lining of the duodenum, by the action of the bile acids on the acid digestive fluid. Since albumen and peptone in an acid solution (as in the urine) are precipitated by the bile acids or their derivative — cholate of sodium — obviously an acid solution of them (of the two, better peptone) may be used as a test for the bile acids. Hence Dr. Oliver has devised the following test-solution, which is antiseptic:

Pulverized peptone (Savery and Moore),	gr. xxx.
Salicylic acid	gr. iv.
Acetic acid	♏xxx.
Distilled water to	f℥ viij.

To be filtered repeatedly until transparent.

To apply the test, the urine must be rendered perfectly clear, by boiling or filtration if necessary, and rendered acid if alkaline; and the specific gravity reduced to 1008 if above it. Then to 60 minims of test-

---

[* "Lancet," March 7, 1885, *et seq.*, and "Bedside Urine-Testing," third edition.]

fluid 20 minims of urine mixture are added. If bile salts are present in subnormal or normal quantity, there is no immediate reaction, but in a little while a slight tinge of milkiness is produced. If they are present in abnormal amount, a distinct milkiness promptly appears, becoming more intense in a moment or so, the degree of opacity being proportionate to the amount present. On agitation the opalescence diminishes, and may disappear, but reappears on the addition of more reagent. On this fact he bases a rough quantitative test, for which he prepares a standard solution by adding equal parts of test-fluid and normal urine mixture of specific gravity 1008. Any urine requiring 60 minims or more to bring its opacity up to that of the standard does not contain an excess of bile acids. He has prepared a standard table as follows:

					INCREASE OF PERCENTAGE.	
If 1 minim	or 2	drops	are required,	. .	6,000	times.
2 minims	or 4	"	"	. .	3,000	"
3 "	6	"	"	. .	2,000	"
4 "	8	"	"	. .	1,500	"
5 "	10	"	"	. .	1,200	"
10 "	20	"	"	. .	600	"
15 "	30	"	"	. .	400	"
20 "	40	"	"	. .	300	"
25 "	50	"	"	. .	240	"
30 "	60	"	"	. .	100	"
35 "	70	"	"	. .	83	"
40 "	80	"	"	. .	66	"
45 "	90	"	"	. .	50	"

An increase over 700 per cent. is rarely found in urine.

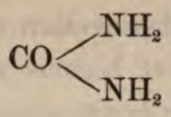
This test is so delicate that Dr. Oliver detects 1 part of bile salts in 18,000 to 20,000 parts of a solution of sodium chloride. He has also a peptone test-paper with those for sugar and albumen.

The precipitate caused by the bile acids differs from all others produced with this reagent in dissolving on the addition of a drop or so of acetic acid, and by diminishing, but not disappearing entirely, on boiling. If his directions as to the preparation of the urine are carried out, nothing he has yet found in the urine interferes with this test. He finds the bile acids excreted in increased quantity in normal urine during fasting and after exercise, and in pathological urine in jaundice, fever, functional diseases of the liver (acute and chronic biliousness), organic disease of the same (carcinoma, enlargements generally, cirrhosis, and amyloid degeneration), and hæmolytic disease (simple and malarial anæmia and splenic leucocythemia).]

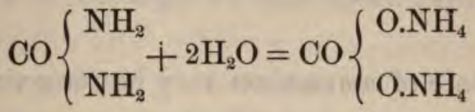
Sometimes, besides the above-mentioned substances, also appear allantoin, especially after use of tannic acid, lactic, acetic, and butyric acids, with acid fermentation, benzoic acid in fetid urine, and sometimes also fat and soap.

6. *Carbonate of Ammonium.*

All the ammonium carbonate, $(NH_4)_2CO_3$, which is found in the urine arises from the breaking down of the urea. Urea is carbamide—



By taking up water, urea is changed into carbonate of ammonium—



$$CO\begin{cases} NH_2 \\ NH_2 \end{cases} + 2H_2O = CO\begin{cases} O.NH_4 \\ O.NH_4 \end{cases}$$

This transformation of urea into $(NH_4)_2CO_3$ is the explanation of the generation of ammonia by the changes of the urine through decomposition under some circumstances in the bladder. A body adhering to the mucous membrane of the bladder acts as a ferment under certain conditions. This is especially the case in bladder catarrh. We find that in most bladder affections the urine possesses an alkaline reaction. The catarrhal secretion from the pelvis of the kidney does not appear to give rise to an alkaline fermentation of the urine, except in very advanced stages. We consequently find that in pyelitis, in contradistinction to bladder catarrh, the urine almost always has an acid reaction. If we take two equal parts of fresh normal urine and add to one the sediment from a freshly-passed pyelitic urine, and to the other the sediment from a freshly-passed cystitic urine, and allow them to stand, at first we observe an acid reaction in both urines; but after a short time the urine mixed with bladder secretion begins to lose its acid reaction, and in two or three hours will have become distinctly alkaline, while the urine with the pyelitic secretion still possesses an acid reaction, and does not become alkaline usually until twelve to twenty-four hours afterward.

Carbonate of ammonium appears in the second stage of acute exudative processes as the so-called resorption urine, which may be regarded as a favorable symptom.

Carbonate of ammonium may be recognized by its odor. Urine containing this shows generally an alkaline reaction. Since, however, the alkaline reaction may be caused by one of the fixed alkalies, as carbonate of sodium, which may have been taken internally, and we are in doubt as to the origin of the alkalinity of the urine, we may apply the following test:

Pour into a flask of 100 c.c. capacity 15 to 20 c.c. of the urine to be analyzed, and close the flask with a cork through which is passed a glass tube the thickness of a lead pencil. Into this introduce a strip of moistened litmus paper, and gently warm the flask on a water-bath. If ammonia is present, it will be drawn off with the steam, and the red litmus paper will be colored blue. In this way we are able to recognize a very small quantity of ammonia in the urine. Care must be taken that the urine does not boil, for then the urea would be decomposed and ammonium carbonate would be formed. Carbonate of ammonium is present—

(1.) Usually with the various bladder affections.

(2.) In the second stage of acute exudative processes (resorption urine).

According to Heller, ammonium carbonate is present also in spinal affections and in severe typhus, the urine possessing an acid reaction.

7. *Sulphuretted Hydrogen.*

Sometimes we find in albuminous urine, especially with bladder catarrh, where a great amount of pus is produced, sulphuretted hydrogen (H_2S). It is formed from the decomposition of the albuminous bodies within the bladder. Although this may be recognized by its odor alone, it can be proved chemically by the same means above described for the detection of carbonate of ammonium. Instead of the litmus paper that we employed above we must substitute a strip of white filter paper moistened with a drop of a solution of lead or silver salts. Upon the addition of the slightest heat the H_2S escapes and colors the white paper in the tube black-brown. These urines are betrayed by coloring silver catheters black.

8. *Accidental Constituents.*

By accidental constituents of the urine we understand those bodies which are exceptionally taken into the organism and evacuated by the urine.

Many substances undergo no essential change in the organism, including most inorganic compounds, also many organic (succinic acid, chloroform, quinine, phenol, etc.).

After continued use of the heavy metals and their salts, and also after continued employment in contact with them (as color-workers, potters, etc.), antimony, arsenic, copper, zinc, gold, silver, tin, lead, bismuth, and mercury have been found in the urine.

The alkali salts taken internally appear in the urine —the alkali carbonates, ammonium salts, chlorates, borates, and silicates of the alkalies, ferro- and ferricyanide of potassium, potassium cyanide and iodide, etc. Sulphur-hepar is excreted as a sulphate. Calcium and magnesium salts pass in but very small amount into the urine.

The mineral acids (sulphuric, nitric, phosphoric, etc.) become for the most part excreted as the corresponding alkali salts. Only carbonic acid occurs free to any great extent in the urine.

The metallic bases, which exist in but minute quantity in the urine, may be separated by the usual quantitative analysis or by electrolysis. Arsenic may usually be detected by treating the urine with H_2S gas and applying Marsh's test to the precipitate.

Many compounds, especially organic, undergo an important change in the organism. The aromatic acids, for example, are excreted as glycocol combinations, just as benzoic acid is excreted by the urine as hippuric, and salicylic as salicyluric acid.

The alkaline carbonates are found in the urine—

(1.) After their internal exhibition.

(2.) After use of sodium mineral waters.

(3.) After a plentiful fruit diet, as the salts of vegetable acid are easily changed in the organism to carbonates.

In these cases the reaction of the urine is alkaline. Whether this alkalinity is due to the breaking up of the urea, or has its origin from the fixed salts, we may determine by methods given on p. 48.

We may also pour 10 c.c. of urine into a porcelain dish, and evaporate the same to dryness, dissolving the residue in a few drops of water. If this residue gives a strongly alkaline reaction, it is due to the presence of the fixed alkalies in the urine. If the residue gives an acid reaction while the fresh urine has an alkaline reaction, the alkalinity is due to $(NH_4)_2CO_3$, which is decomposed by evaporation. If we suspect the presence of other alkali carbonates, as well as the unstable ammonium carbonate, we must first test for the $(NH_4)_2CO_3$ in a flask as before described, and then test for the others in a porcelain dish.

Iodine is very easily detected. If we add to a little urine in a test-tube some carbon disulphide (CS_2), and drop in bromine water or a small amount of fuming nitric acid, and after the addition of each drop close the test-tube with the thumb and invert, the violet color of the carbon disulphide (or chloroform) indicates the presence of iodine.

We may also add to the urine thin starch paste and then a drop of HNO_3. A blue or bluish-black color indicates the presence of iodine. Often, with Heller's test for albumen, iodine crystallizes out, partly on the side of the glass at the border of the albumen zone, and partly on the bottom of the vessel.

Salicylic acid may be recognized by the violet color the urine assumes upon addition of ferric chloride. This is best recognized as follows: We add to 1 c.c. of a concentrated ferric-chloride solution in a test-tube 10 c.c. of urine, and note the reaction. A similar reaction occurs, however, in many diabetic urines. (See p. 120.)

D. THE SEDIMENT.

Urine Fermentation.

Normal urine is clear when passed. After standing there forms on the bottom or lower half of the urine the so-called nubecula, a slight cloud of bladder mucus, which is easily distinguished if we hold the glass vessel against a dark background, as the sleeve of the coat, especially when in the mucus-cloud epithelium, bacteria, or the delicately precipitated urates are suspended.

A healthy urine, if kept in a perfectly clean vessel exposed to the air (but better if air is excluded), will remain in this condition a long time (weeks or months).

Often there takes place in the urine a change known as acid fermentation.

The urine, besides the urate, contains the acid phosphate of sodium. If, now, this salt of phosphoric acid acts upon the sodium urate so that it extracts one part of the sodium, there results an acid salt of uric acid, which is difficultly soluble and falls to the bottom as a reddish-yellow or clay powder. This happens especially at a low temperature, but at a high temperature the decomposition process goes even farther; the uric-acid salt is deprived of all its base (sodium), and the almost insoluble uric acid separates in beautiful distinct crystals, which are more or less brick-red or dark brown, and fall to the bottom as a granular powder, a part sticking to the side of the vessel and part floating on the surface. Sometimes the uric-acid crystals are mixed with the amorphous powder of the undecomposed urates—*sedimentum lateritium.*

While this process is going on no free acid is formed, as testing will prove. With the urine sediment in most cases more or less small or great crystals of calcium oxalate are mixed (Pl. III., A). A part of the uric acid is in the organism transformed to oxaluric acid, which by long standing and exposure to air becomes oxidized in the urine to oxalic acid, which appears in the sediment as calcium oxalate. (This process, as may be understood, does not deserve the name of fermentation, though in a few cases a true fermentation appears, with formation of acetic acid.)

When the decomposition of the phosphates and urates is ended, there follows after a short time a new process. The urine becomes paler; the crystals of uric acid have disappeared; the acid reaction changes first to neutral, then to alkaline; the urine gives off a strongly ammoniacal odor, becomes more and more turbid, and a whitish sediment falls, which no longer consists of urates, but of the phosphates of the alkaline earths. By means of the microscope we find that this turbidity is not caused simply by the finely powdered suspended phosphates, but also by a multitude of partly quiet and partly ever-moving bacteria. This process is the characteristic or alkaline fermentation of the urine (Pl. IV., B). It is based upon the destructibility of urea by a peculiar ferment discovered by Musculus (Hofmann, l. c., 400).

Musculus recommends a paper saturated with the ferment as a very sensitive reactive for urea. The thick-flowing alkaline urine as it comes from bladder catarrh is filtered; the filter paper which was used is washed with distilled water until it has no longer an alkaline reaction, dried, and colored with turmeric. The urea itself does not react on turmeric, but the urea is decomposed by the absorbed ferment, and the paper is colored brown by the resulting ammonium carbonate.

Ammonia can combine with uric acid as urate of ammonia, which appears crystallized as single or double spheres with a smooth or thorny surface. If the ammonia formation goes on, then a part of the ammonia joins with the phosphate of magnesia and forms beautiful crystals of triple phosphate. The phosphate of calcium dissolved in acid fluid falls to the bottom in an alkaline solution. The sediment then of the alkaline urine consists of an amorphous mass of phosphate of calcium, together with crystals of triple phosphate; at the beginning of the process also urate of ammonium is present.

Blood and pus mixed with urine, as well as uncleansed vessels which have contained fermented urine, cause rapid decomposition of the same without having previously passed through the so-called acid fermentation. Bacteria accompany this process, and well-developed mold can be observed on the surface of the urine after it has stood for a time, especially on a hot day.

Classification of the Sediment.

As long as the formed constituents of the urine are distributed throughout the fluid they produce *turbidity* of the same; as soon as they sink to the bottom they form the *sediment* or *precipitate.* Precipitation occurs in different urines with various degrees of rapidity: faster in thin than in thick albuminous urines; more quickly if the materials are heavy solids, such as crystals of uric acid or the urates; more slowly if they are light, as epithelium and delicate hyaline cylinders. The constituents of the sediment are either excreted in their present state from the bladder and only need to settle, or they may have had their origin in the evacuated urine.

The elements of which the sediment is composed are either organized forms—and these appear as well in acid as (somewhat changed) in alkaline urine—or unorganized, partly amorphous, partly crystalline forms, some of which are found in acid and others in alkaline urine.

Accordingly, we may classify all the sediments as follows:

SEDIMENTS.

I. *From acid urine.*	II. *From alkaline urine.*

A. NOT ORGANIZED.

a. Amorphous:

1. Urates of sodium and potassium.	1. Calcium phosphate.
2. Fat.	2. Calcium carbonate.

b. Crystalline:

1. Uric acid.	1. Ammonium urate.
2. Calcium oxalate.	2. Triple phosphate.
3. Cystine.	3. Calcium phosphate.
4. Tyrosine.	4. Magnesium phosphate.

B. ORGANIZED.

1. Mucus- and pus-corpuscles.
2. Blood-corpuscles.
3. Epithelium from the various tracts of the urinary apparatus.
4. Cylinders (or casts) and fibrine coagula.
5. Spermatozoa.
6. Carcinomatous tissue.
7. Entozoa.
8. Fungi.

These constituents will be considered according to their form and the frequency of their occurrence.

The Unorganized Sediment.

1. *Urates.*

Uric acid is combined in the urine with sodium and potassium, and forms in the sediment salts of varying composition; for by a loss of part of the base (as we have described in the so-called acid fermentation) an acid salt arises, which is difficultly soluble and always tends to precipitate.

The urates are more soluble in warm water than in cold, and the neutral salts are more soluble than the acid. Therefore it follows that the urates are most easily precipitated, if we add a strong acid which will deprive the neutral salts of part of their base, forming acid salts which are so difficult to dissolve. These become more easily precipitable the colder the fluid and the less the bulk of the urine. The formation of the urate sediment is favored by the three following conditions:

1. *Moderate acidity of the urine* (by too strong acid reaction uric acid is precipitated), or the action of acid mineral salts (the so-called acid fermentation).

2. *Concentration of the urine*, whether it be by addition of uric acid or by deprivation of water.

3. *Cooling of the urine*, which condition may occur in the evacuated urine or in the dead body.

The neutral alkali urates form an amorphous powder, which from the accompanying coloring matters appears yellowish, grayish-brown, or rose-red to brick-red (*sedimentum lateritium*). Under the microscope they have the appearance of fine granules joined together, resembling moss in structure. (Pl. V., B.)

If there are strips of mucus on the object-glass with these granules imbedded, the beginner is liable to mistake them for granular casts. They may be distinguished by a less sharp contour, a less bodily consistence, and especially by the reaction of gentle heat.

The sediment of urates disappears by application of heat. Should a residue remain, it is proved to be pure uric acid. Upon addition of some alkali (KOH or Na OH) and heat this also disappears.

From this peculiarity of the urates they are distinguished from pus and the phosphates. The phosphates can not be observed, however, if the urine is acid. In weakly alkaline urine, especially when made alkaline by KOH, on application of heat the phosphates precipitate.

If the urine contains pus, it will not clear up by heating, but on the contrary the coagulated albumen renders it more turbid. (The alkalies prevent this coagulation.)

Finally, we may also test the dried sediment by means of the murexide test (p. 57), or prove the presence of urates by a pretty microchemical test, as follows: Add upon an object-glass to the spread-out urates a drop of hydrochloric acid, and in a short time observe the crystals of uric acid form in the field of the microscope.

Sometimes we observe in the urine which has undergone the so-called acid fermentation, and is about to pass over into the alkaline, that the partly dissolved crystals of uric acid are set upon the prismatic crystals of acid sodium urate.

A rare precipitate of crystalline acid urate of sodium is observed sometimes in the strongly acid urine of children, the needle-like crystals being arranged in groups resembling sheaves of wheat.

2. *Urate of Ammonium.*

The acid ammonium urate is the only urate which is found in alkaline urine in connection with amorphous calcium phosphate and the triple phosphate crystals.

Ammonium urate forms brown-colored spheres, which may develop singly or as double spheres, or which may exhibit a conglomeration of kidney-formed surfaces. The surfaces of such forms are smooth, or are studded with sharp points, resembling thorn-apples. The prolongations may be long, branching, and bent, thereby forming a multitude of similar shapes (turnips, spiders, many-rooted teeth, etc.). (Pl. IV., B.) These forms are so characteristic that the observer after using the microscope remains no longer in doubt as to the nature of the sediment.

The quantity generally admits of a few microchemical tests.

If a drop of HCl is allowed to flow under the glass cover, the original bodies disappear, and after a short time we see the very small rhombic crystals of pure uric acid formed. If KOH is added instead of HCl, we observe the formation of bubbles from the liberated ammonia. The urate of ammonia gives like the others the murexide test (p. 57).

3. *Uric Acid.*

The appearance of uric acid in the urine is in part dependent upon the same circumstances as the urates. Normally we find crystals of uric acid at the end of the so-called acid fermentation, also in concentrated urine, especially on summer days, when the higher temperature prevents the deposition of the urates. Finally, a pathological excess is found in those cases where the water and the alkalies do not suffice to retain it in solution.

The primary form of uric-acid crystals is that of rhombic plates with blunt rounded corners. This shape is known as the whetstone crystal. The crystals may be small and singly developed. Sometimes rows of these crystals are deposited on accidental impurities, as threads or hairs, and thus form long cylinders. In other cases the single crystals are developed and joined to foreign matters, where they are arranged upon the edges (fan-shaped) or upon the faces (as tiles). Besides the whetstone crystals, we often find tub-shaped or long pointed crystals joined together in a rosette. (Pl. II., B.)

The rough and pointed forms of uric acid have a great practical significance, inasmuch as they are almost always an accompaniment of renal calculi.*

These forms occur only in strongly acid urine. If the acid urine is neutralized by the internal administration of fixed alkalies, the forms of the crystals are changed, the pointed forms becoming the normal whetstone-shaped crystals.

---

* Ultzmann, "Ueber Harnsteinbildung," in "Wiener Klinik," 1875, 5. Heft.

The rough and pointed forms of the crystals occur in the urine sediment of pyelitis calculosa, and are frequently accompanied by albuminuria (hyperæmia of the kidney) and hæmaturia. We also find these forms present without pyelitis or albuminuria. When this is the case, micturition is sometimes painful. In every case the uric acid is colored light yellow, brown-red, or dark brown by the accompanying coloring matters.

The crystals are generally formed so large that they appear on the bottom of the vessel as a glistening brick-red sand, which may often be seen by the unaided eye.

This sediment dissolves on heating with caustic alkali; partly because some urates are formed, while the remainder of the acid is deoxidized. The sediment gives finally a beautiful murexide reaction.

4. *Calcium Oxalate.*

Oxalic acid has a strong affinity for calcium. Since calcium salts are present in the urine, the oxalic acid which is excreted by the kidney or forms in the urine is observed in combination as calcium oxalate. These crystals result, as already mentioned, from the acid fermentation together with uric acid. The shape of the calcium oxalate is very characteristic. The crystals are generally quadrilateral octahedrons which have a strong refractive power. Sometimes they appear as small but distinctly angular dots, and sometimes as rectangular plates whose angles are joined by diagonal lines, causing the envelope appearance. Some appear oblique. Besides these principal forms, we sometimes observe dumbbell crystals. (Pl. III., A.) As these crystals have a low specific gravity, they appear only after a long time in the sediment—from twelve to twenty-four hours; after this time has elapsed we must carefully decant and look for the small four-cornered dots.

The characteristic form of the crystals admits of no confusion. The only crystals with which they may be confounded are the triple phosphate. In the first place, however, the calcium-oxalate crystals are never as large. Secondly, calcium oxalate occurs in acid urine, triple phosphate appears in neutral or alkaline. Finally, acetic acid dissolves the triple phosphates, but has no action on the calcium oxalate.

5. *Cystine.*

Cystine forms regular hexagonal tables of varying size. These occur singly, or we find a large plate at the bottom, and smaller and smaller plates as the series ascends; we also observe a shingle-like series. Sometimes a large crystal breaks, showing the hexagonal cleavage to be still preserved. Small, imperfectly developed crystals form irregular lumps. Often the corners of the plates are rounded as if melted off. The crystals are always colorless. (Pl. VI., A.) These crystals can only be confounded with a pure, colorless, rarely occurring form of uric acid. This similarity is observed when the cystine is precipitated by acetic acid; for, when uric acid is precipitated in the same manner, the forms are similar six-sided plates, but generally not as regular.

In order to ascertain if our crystals under the microscope are cystine, we carefully allow a drop of ammonia to flow under the cover-glass. Instantly the crystals of cystine vanish, while uric acid without the application of heat remains unchanged. As soon as the ammonia has evaporated, the cystine again crystallizes. The reprecipitation is assisted if we add a drop of acetic acid to the ammoniacal solution.

A second test consists in treating the cystine crystals with a drop of hydrochloric or oxalic acid. Cystine dissolves, while the uric acid will remain unchanged.

The form of the crystals and their insolubility in boiling water prevent cystine from being confounded with the urates.

Cystine is soluble in ammonia, but insoluble in carbonate of ammonia. In case the cystine is held in solution in the acid urine at the beginning of the alkaline fermentation, it is precipitated like an earthy phosphate by the carbonate of ammonia generated.

From the earthy phosphates and triple phosphate cystine is easily distinguished by chemical tests, and by the microscope, which shows the earthy phosphates as an amorphous powder, while the triple phosphate presents an entirely different form of crystals.

Acetic acid dissolves the earthy phosphates, but the cystine is unaltered by it. But, if it happens that by addition of acetic acid and heat the greater part of the sediment dissolves and but a trace remains, this should be brought under the microscope; and, if hexagonal plates appear, they should be treated in the above described manner with ammonia and hydrochloric acid, to distinguish the cystine from uric acid.

If we dissolve cystine in KOH, warm, add water, and then a solution of nitro-prusside of sodium ($Na_2(CN)_5(NO)Fe''$), the mixture becomes violet. This reaction also will show albumen or any other compound containing sulphur in the dyad form.

The urine in which we find cystine is mostly pale. When putrefying it develops, besides the ammoniacal odor, that of hydrogen sulphide, which in all probability occurs as a decomposition product of the cystine. The sediment of cystine occurs in connection with cystine stone, and also independently of it. It appears white or dirty yellowish-gray, often with an abundance of triple phosphate and phosphate of calcium; in acid urine, with calcium oxalate.

This sediment seldom occurs with us, but it sometimes happens that many members of a family suffer from cystinuria.

6. *Leucine and Tyrosine.*

Both of these substances are usually found together in the urine, but mostly in solution. Simple evaporation serves to produce a sediment (p. 124). Tyrosine sometimes appears as a sediment without this treatment.

Under the microscope leucine appears as spheres of various sizes, more or less colored, and having the appearance of large drops of fat. They are sharply defined, and show in a favorable light fine radiating stripes and also delicate concentric lines.

Tyrosine forms very fine short needles, made up into sheaves or bundles crossing each other at various angles. (Pl. IV., A.)

Sometimes leucine spheres are distributed throughout this formation. The addition of a drop of ether will prevent confusion of the leucine with fat-globules, for fat is dissolved by the ether. The crystals are soluble in caustic alkalies, but not in cold mineral acids.

Tyrosine crystals can be identified in two ways, by Piria's and Hofmann's tests. The first method consists in placing a small amount of the sediment in a watch-glass, and moistening with a few drops of concentrated sulphuric acid; after an interval of twenty to thirty minutes add some water and neutralize the solution with calcium carbonate as long as it effervesces, and then filter. If, on the addition of ferric chloride which is free from acid, a violet color is produced, tyrosine is present.

The second method is still simpler. The sediment is diluted with water and boiled; to the boiling fluid add a few drops of mercuric-nitrate solution. If a red precipitate falls and the supernatant fluid is rose- or purple-red, tyrosine is present. Leucine and tyrosine occur in the urine very infrequently, seldom otherwise than with acute yellow atrophy of the liver and phosphorus-poisoning.

7. *Fat.*

The fat-globules which float on the surface of many urines must not be regarded as coming from the urinary organs. We often find that the patient has been catheterized, and the fat has come from the oil used to lubricate the catheter. We must also be careful regarding the finely divided fat-globules under the microscope; they are apt to be from unclean object-glasses, or from the urine having been collected in greasy bottles which have previously contained hair oil or some fatty emulsion, medicines, etc., or to be caused by milk having been emptied into the vessels used for the urine.

The assertions that entire fat-globules appear in the urine with excessive fatty degeneration of the kidney, we are unable to confirm by our personal observation.* An emulsion of fat is observed in the chylous urine of the tropics (galacturia), partly causing its turbidity. The turbidity from these causes is cleared up by shaking with ether. In such urine the sediment is peculiar; as the specific gravity of the urine is higher, the sediment will rise to the surface as a cream. The fat shows under the microscope various large spheres with sharp contours. Ether dissolves it. Cholesterine occurs sometimes along with the fat, but very rarely, and for the most part in a crystalline form, recognized by the clear, large rhombic plates. In Europe galacturia occurs very seldom.

[* Dr. Tyson claims to have observed the fat-globules referred to in the text. Dr. Roberts observed free oil after the exhibition of cod-liver oil, and Dr. Henderson in three cases of heart-disease. Dr. Cushing found considerable quantities of pure oil in the urine of a case of left lumbar abscess opening into the ureter.]

[In England there have been several cases of chyluria reported,* some of which occurred in persons who had never been out of the country; and in some of them the urine at times seemed rather lymphous than chylous (i. e., the fat is absent, but albumen and fibrine remain—the milky appearance being absent, but the capability of forming a clot spontaneously also remaining [fibrinuria]). The pathology of these cases is obscure. In chyluria, as observed in the tropics, where it is endemic, the symptoms may be of a very slight nature, with an intermittent character to the disease, and the patient's general health may suffer very little, or, there may be severe symptoms, such as renal colic or strangury, and the long-continued drain on the system may produce exhaustion and pave the way for grave intercurrent disease. In the urine of persons contracting the disease in the tropics, the filaria sanguinis hominis is so often found as to suggest a causal relation between it and the affection.]

8. *Earthy Phosphates.*

a. Amorphous.—In ammoniacal urine we find regularly a heavy precipitate of grayish-white sediment, which the beginner often mistakes for pus. This sediment is the precipitated earthy phosphates, i. e., calcium and magnesium phosphates. As we have said, these salts are only soluble in acid fluids, and consequently must have been precipitated from the time when the

---

[* Roberts (*op. cit.*, p. 335 *et seq.*).]

urea changed to carbonate of ammonium, thereby rendering the urine alkaline. Under the microscope the earthy phosphates appear as granules of various sizes, which do not form the mossy groupings that characterize the urates. Their identification chemically is very easy. The urates, with the exception of urate of ammonium, occur in acid urines, while the earthy phosphates (the crystalline calcium phosphate which occurs in acid urine being excepted) are found only in alkaline urine. The reaction with litmus settles the question as to whether we have to do with urates or phosphates. By heating, the urates disappear while the sediment of the phosphates increases. By addition of KOH or Na OH the urates dissolve, while the phosphates remain unchanged.

The distinction between phosphates and pus is shown in Donné's test. (P. 171.)

All circumstances which lead to alkaline fermentation of the urine, or cause the alkalinity of the same, tend to the formation of the sediment described, which is precipitated in mass proportional to the amount of the earthy phosphates in solution.

Only exceptionally, with bladder catarrh or after the use of a great amount of alkalies, is the urine alkaline upon evacuation. In these cases it is already turbid from the precipitation of the earthy phosphates thrown down in the bladder. Generally the turbidity appears only a shorter or longer time after evacuation of the urine. These amorphous earthy phosphates are often mixed with a beautiful combination of magnesium phosphate with ammonium—the so-called triple phosphate.

b. Crystallized calcium phosphate.—Crystalline calcium phosphate, of the formula $PO_4\ HCa + 2H_2O$, is found in pale weakly acid urines, which have a tendency toward alkaline fermentation.

This sediment appears with some persons as an individual peculiarity oftener than from other causes. We have observed individuals living under healthy normal conditions to have in summer a daily sediment of crystalline calcium phosphate in the urine.

PKW

Under the microscope the crystals appear club-shaped, with broad oblique bases. They may be isolated, or may lie over one another, the points converging together, often forming a rosette, the periphery being formed by the bases of the crystals.

In some cases the crystals do not simply form circles, but make up segments of spheres. (Pl. III., B.) (Other forms are described in K. B. Hofmann's "Zoochemie.")

The forms of the crystals are so characteristic that confusion is hardly possible. The triple phosphates which may accompany them in later stages of alkaline fermentation have no points, and moreover form no bouquets or rosettes.

From uric acid this sediment may be distinguished by the fact that it is colorless and disappears on addition of acetic acid.

9. *Magnesium Phosphate.*

In neutral or weakly alkaline urines, which we observe after the internal use of the fixed alkali carbonates or mineral waters containing them, appear long quadrilateral tables of basic magnesium phosphate, $Mg_3(PO_4)_2 + 17H_2O$, two opposite angles of which have been truncated. If we allow a drop of a solution of commercial ammonium carbonate, in five parts of water, to flow over these crystals beneath the cover-glass, they become opaque, and appear like rough leather gnawed on the edges.

Calcium phosphate does not become opaque, and is more slowly affected by such treatment. Triple phosphates are not altered.

This sediment is very rare, and can only develop in urine which is strongly concentrated and is originally neutral or alkaline. If the urine becomes alkaline from the urea decomposition, there is naturally no magnesium phosphate, but we have ammonio-magnesium phosphate.

10. *Triple Phosphates.*

These appear as large, clear, refracting crystals, with distinct smooth surfaces and sharp edges. Among the many combinations of the rhombic and very frequently partially amorphous shapes, the coffin-lid crystals are the most common. (Pl. III., B.) They might be confused only with sodium chloride or calcium oxalate; but sodium chloride only appears as crystals in evaporated urine. From calcium oxalate they may be distinguished by adding a drop of acetic acid; if the sediment dissolves, it is triple phosphates; if it remains unchanged, it is calcium oxalate. The conditions under which these occur have been spoken of under earthy phosphates.

11. *Calcium Carbonate.*

The urine of most herbivora is already cloudy when evacuated. The turbidity arises from the mass of the excreted calcium carbonate. Only exceptionally is such a condition found in man, though it sometimes occurs a short time after the urine is evacuated. The causes of this are somewhat obscure.

This sediment does not come down by itself, but in connection with the earthy phosphates, forming a more or less fine grained powder, and sometimes dumb-bell crystals. (Pl. VI., B.) We can recognize this precipitate by its solubility with effervescence on addition of mineral acids. This may be observed under the microscope. If, by placing a thread or a hair under the cover-glass, we allow a drop of HCl to reach the sediment, then we see gas bubbles of carbonic acid developed. This reaction is never observed with pure earthy phosphates. The sediment must be previously washed carefully with water on a filter to remove any ammonium carbonate (which with acids would also cause effervescence).

Organized Sediment.

1. *Mucus.*

Considerable mucus may be contained in the urine and not be noticed, because of its transparency, and the slight difference of its refractive power from that of the urine. Only after long standing, when the urates begin to come down, when the urine contains more epithelium than usual, or when there is a rapid and considerable development of bacteria, does the mucus form the before-mentioned nubecula.

If these conditions are not fulfilled, we color the urine.

If there is no albumen in the urine, we precipitate the mucus with alcohol to which some tincture of iodine has been added, as a stringy mass. Or the mucus may be precipitated by acetic acid to which has been added a little of a solution of iodine dissolved in potassium iodide. The acetic acid causes a turbidity of the mucine in solution, which is not affected by an excess of this acid, but which vanishes upon addition of a couple of drops of HCl.

If the turbidity of the urine disappears by application of heat, we know it was not due to mucus, but to the urates. Mucus has no characteristic form under the microscope; we find only crystals of oxalate of lime and uric acid, as well as mucus-corpuscles (young cells) or bladder epithelium which have been held in suspension by the mucus.

Mucus coagulated by acetic acid, however, shows under the microscope a granulated mass, for the most part striated bundles, sometimes simulating casts and cylinders.

In women we generally find a much greater nubecula, because the urine is usually mixed with a great quantity of vaginal mucus, especially with fluor albus.

Since mucine only swells in water and undergoes no real solution, we may separate it from the urine by filtration. The mucus remains on the filter, and appears there when dry as a glistening varnish. Urines containing much mucus filter badly, for the reason that the pores of the paper are stopped.

2. *Epithelium.*

We have already mentioned the young cells as mucus-corpuscles. Other cells appear in the urine which serve as an epithelial covering for the mucous membrane of the urinary apparatus, or as the proper glandular tissue of the kidneys.

Manifold as the forms of the epithelial cells appear, if we examine the various parts of the urinary apparatus, we do not find all these forms represented in the urine. The urine, as a fluid containing various salts in solution, works a change upon the epithelial cells. Three forms may with certainty be distinguished: 1. Round cells; 2. Conical and caudate cells; 3. Flat cells.

1. *The round cells* arise from the tubules of the kidney, and from the deeper layers of the mucous membrane of the kidney-pelvis. In their original form they are more or less oppositely flattened, corresponding to their position beside one another. (Pl. I., A, 1.) Under the influence of the urine they swell and become globular. They have a clearly defined nucleus, and are by this easily distinguished from the pus-corpuscles which also appear in the sediment. The pus-cells are

uniformly granulated, and show their nuclei with distinctness upon addition of acetic acid. The epithelial cells contain but one nucleus, the pus-cells two, three, and sometimes more; besides, the epithelial cells are larger.

In acid urine the epithelial cells are preserved a long time, but if the urine is neutral or alkaline they appear greatly swollen, nearly hyaline, the granular protoplasm entirely surrounding the nucleus; after a time they become wholly dissolved. The epithelium of the male urethra is very similar to the kidney epithelium, so that it is difficult to distinguish one from the other under the microscope. (Pl. I., B, 1.) The distinction is usually based upon the chemical constitution of the urine. If the urine contains albumen, the round cells are due to a desquamation from the urinary tubules. If albumen is not present, the round cells are probably from the urethra.

The epithelium of the prostate, Cowper's, and Littré's glands is similar to that of the urethra, and can not be distinguished from it microscopically. With mucus and pus the epithelium forms the so-called gonorrhœal threads. (Pl. VI., A, 2.)

2. *The conical and caudate cells* have their origin in most cases in the pelvis of the kidney. Very delicate cylindrical cells come also from the accessory organs of the male urinary apparatus, though they are of rare occurrence. The cells are generally twice as long as broad, and are smaller at one end than at the other. The caudate cells may have a prolongation on one end

(unipolar), or they may have spindle-shaped prolongations on both (bipolar caudate cells). (Pl. I., A, 2.) The presence of these cells must not be regarded as an indication of a neoplastic growth, as is stated in the older writings.

3. *The flat cells* arise either from the bladder or the vagina. They are most irregular, polygonal with rounded corners, and have a sharply defined dark nucleus nearly in the centre. This nucleus bulges out, as may be seen when the cell is standing on its edge, making the cross-section appear like a spindle-cell. (Pl. I., B, 2.)

It is difficult sometimes to distinguish the bladder epithelium from that of the vagina. The bladder epithelium is more delicately formed, and generally appears singly; the epithelium of the vagina is somewhat coarser, has sometimes a warped surface, and is almost always cast off in great cohering shreds; frequently the scales are arranged in layers, an appearance never occurring in bladder epithelium. (Pl. I., B, 4.)

The yellow color of the nuclei of various epithelial cells with icterus is interesting. If we now allow a drop of fuming nitric acid to flow under the glass cover, we observe the nuclei to pass through the color changes of Gmelin's test (green, blue, violet, etc.) (Ultzmann).

3. *Pus-corpuscles.*

The pus-corpuscles of the urine are quite similar in appearance to those of a suppurating wound. They are round cells twice as large as blood-corpuscles, with a uniformly granular exterior which surrounds the nuclei. The nuclei may be exhibited more distinctly by the addition of a drop of acetic acid under the cover-glass: the granulation vanishes, the corpuscle swells, and the several centrally placed nuclei become visible. Besides this usual form, there is another of rare occurrence, in which the corpuscles are not round, but have various prolongations which show amœboid movement. (Pl. VII., B.)

The pus-corpuscles are changed, especially in ammoniacal urine, under the influence of carbonate of ammonium. They swell up and coalesce, showing under the microscope a homogeneous mass, in which the nuclei alone are distinguishable. Such pus forms a vitreous, slimy mass, which on pouring flows out as a whole, like albumen when poured from one vessel to another.

This must be distinctly emphasized, lest the beginner fall into error in supposing that such a slimy mass is mucus or albumen. The latter does not form a sediment under any conditions, and mucus never forms a like cohering mass. If pus is in the urine, pus-serum and albumen must also be present. We may always obtain the albumen-test, which is not the case with mucus.

The amount of pus-corpuscles is various. Often the urine contains so few that they (forming no sediment) escape the unaided eye. In some urines so much pus is present that a sediment several fingers high is formed of a yellowish or grayish white color.

A confusion with the urates is possible in acid urines, and with the phosphates in alkaline. We have already described the tests for the urates. The phosphates disappear on addition of a few drops of acetic acid; pus does not.

Donné's test permits the distinction without the aid of the microscope. Pour the urine from the sediment, and add a little piece of caustic soda or potassa. If the sediment consist of pus, then it will lose its white color, becoming greenish and vitreous, first stringy, then thicker, until finally it forms a cohesive lump. It has in this manner taken on the appearance of pus in a strongly alkaline urine. Since no other body in the urine can give this reaction, it is a perfectly safe method of distinguishing pus. If the amount of pus is scanty, one can not expect to obtain the cohesive lump, but on the contrary the sediment disappears and the fluid becomes vitreous and stringy.

With the sediment are mixed broken-down pus-corpuscles (detritus), and frequently blood-corpuscles, epithelial cells, etc.

4. *Blood-Corpuscles.*

Blood-corpuscles in the urine may be distinctly recognized when present in but small amount. If the urine is tinged a brownish red, and the suspicion arises that blood-coloring matters or corpuscles are mixed with it, we allow it to stand for some time, in order that the light and sparingly present blood-corpuscles may form a sediment (often but a trace), which is colored a beautiful red.

In acid urine the blood-corpuscles retain their characteristic form for a long time. They exhibit small disks, which show a central shadow corresponding to the depression. If the blood-corpuscles stand on their edges, they appear bi-concave. They are always single (except in profuse hæmorrhages from the bladder, when they form rouleaux), and appear reddish with a slight greenish tinge.

This original form of the blood-corpuscle undergoes many changes, brought about by the nature of the menstruum in which the corpuscles are distributed. If the urine is very dilute, especially if it has begun to be ammoniacal, the corpuscles swell, the depression disappears, and they become spherical, appearing somewhat smaller than before. The central shadow vanishes with the depression, and instead the corpuscle has a peripheral shadow by which it is recognized as a sphere.

By longer exposure to the above influences, the corpuscle becomes more indistinct and appears as a delicate bubble, which then becomes but a mere shadow in the field, finally disappearing.

By treatment with a neutral-salt solution the blood-corpuscles become smaller and jagged. These jagged forms are observed in the urine, often in connection with the normal. The corpuscles appear to have produced within themselves small crystals whose ends cause the limiting membrane to become distorted. (Pl. V., A, 2.) Sometimes the corpuscles are not round but oval, and are of various sizes in the same urine; sometimes cup-shaped.

In hæmaturia which accompanies parenchymatous affections of the kidney and bladder, we find almost always spherical corpuscles of different sizes. Quite small, even dust-like blood-corpuscles (microcytes) occur in such cases with normal and greater forms (macrocytes).

No matter how small an amount of blood-corpuscles is present, it is always possible to prove the presence of albumen in connection.

If the blood-corpuscles have been dissolved in an ammoniacal urine, we may test for the coloring matters (hæmo- or methæmo-globine), as described on page 128.

Regarding the origin of blood-corpuscles in the urine, the subject is treated of in Chapter VIII.

5. *Cylinders.*

The identification of cylinders plays a most important part in the diagnosis of kidney diseases; for by their form they betray their place of origin in the urinary tubules. In the investigation of the urine, the greatest care must be taken that these be not overlooked. By their low specific gravity they remain for a long time suspended in the urine. To this may be added the circumstance that their appearance is generally accompanied with albuminuria, and in the albuminous fluid their precipitation is very slow.

The precautions necessary for the investigation of these forms are as follows: The urine must be permitted to stand for several hours, then carefully decanted, and the residue shaken up in a pointed sediment-glass, and allowed to stand again one or two hours. The last drops of the sediment should be brought under the microscope. One should never be satisfied by one examination, as the number of cylinders is always small and may be overlooked on hasty investigation. While, on the one hand, we must exercise caution not to overlook the cylinders, on the other hand we must not mistake for them materials of an entirely different nature. Beginners are apt to see granular cylinders in every accidental cylindrical arrangement of the phosphates or urates, especially if imbedded in stripes of mucus.

Although cylinders are generally accompanied by albuminuria, there is albuminuria with which no cylinders are found, and there are isolated cases in which cylinders are present without contemporaneous albuminuria. Examples of the first case are the albuminuria of interstitial nephritis, of amyloid kidney, and renal stasis; as an example of the second condition, severe inflammatory processes are to be mentioned, in which the cylinders precede albuminuria from twelve to twenty-four hours.

Among the numerous cylinders the chief forms (partly passing into one another) are the following: 1. The ordinary fibrine cylinder; 2. The fine granulated cylinder; 3. The hyaline cylinder; 4. The waxy cylinder; 5. The epithelial casts and cylinders; 6. The so-called uric acid cylinder; 7. The bacteria and micrococci cylinders.

1. *The ordinary fibrine-cylinders* are roll-formed,

often spirally twisted clots, with a sharp contour and of a light yellow to brown-yellow color. Their calibre exceeds that of the other casts, so that they may be regarded as having their origin in Bellini's tubes (see Fig. 2), near their outlet upon the papilla; frequently the epithelial cells adhere to them. The blood-cylinders may be regarded as a lower form of the fibrine-cylinder; these consist of clotted blood, and arise from rupture of the glomeruli. These are always dark brown, and appear to consist of a compressed clot of blood-cells. Sometimes we observe on one part of a cylinder a fibrine-clot, while the other is covered with blood-corpuscles. This form is always accompanied with isolated blood-corpuscles in the sediment. (Pl. VII., A, 1.)

2. *The fine dark-granuled cylinders* are smaller than those described above. They appear under the microscope as a solid plug from the more remote urinary tubules. They have sharp contours, and appear, as their name implies, finely granulated throughout; they are rounded off on one or both ends like a finger, appearing uniformly of the same calibre, or constricted as if strangulated. They may be shaped at one end like the neck of a bottle. In the granulations many modifications are to be observed: in some places the granules are coarse, and in others the casts seem to have almost lost their granulations and to have become hyaline. Sometimes fat-globules are mixed with the granulations. Upon the addition of acetic acid, in some cases the granulations disappear, so that the cylinder becomes

clear; in other cases this has no influence whatever. The color of the granulated cylinders is a pale, dirty grayish yellow. (Pl. VII., A, 2.)

Both these forms of casts remain a long time unchanged in acid urine, while in alkaline they gradually become more indistinct and finally disappear.

3. *The hyaline cylinders* are of the same size as the granular casts, or they may be smaller. They are sometimes straight and sometimes curved; the length is often considerable. While at times the appearance of a solid body is unmistakable, again they appear as very delicate tubes cylindrically formed, sometimes ribbon-shaped. Frequently we find spirally twisted cylinders, with one or more turns. (Pl. VII., A, 3.) In the first and greater forms a distinct contour is visible, while the last mentioned forms are difficult to recognize from the surrounding medium, and under the microscope they only appear as a shadow. In such cases it is advisable, in order to bring out their form, to add a drop of iodine dissolved in potassium iodide solution, or aniline violet, by means of which the cylinders appear respectively yellow or blue-violet, and may be better distinguished from the paler surroundings. They show generally no trace of granulation, but are perfectly transparent. From the narrowness of the ribbon cylinders, they are supposed to come from the smaller branches of the urinary canals, perhaps from the fine ascending loops of Henle. The hyaline cylinders disappear soon in alkaline urine.

4. *The waxy cylinders* are about the width of the

granular, perfectly clear and strongly refractive, so that their contour is as sharply defined as the triple phosphates or similar clear crystals. They are straight, broken, or curved. Their surface is often wavy, as if they were made up of coalescent colloidal nodules. In places they show deep indentations, as if the gelatinous mass had yielded to pressure. They give the amyloid reaction, and are tougher than the other cylinders. This form of cylinder is of rare occurrence, and has been found only with amyloid degeneration and tuberculosis of the kidney. (Pl. VII., A, 4.)

5. *The epithelial casts and cylinders* are processes by which the epithelial coating of the urinary canals is stripped as a whole from the membrana propria, and by the *vis a tergo* of the urine or of a fluid exudation is forced out of the tubule. These forms, which are made up of epithelial cells and have a lumen, we term epithelial tubular casts. With these, in the same sediment, we find cylinders made up of hyaline substance covered with epithelial cells. We may find the latter without the former. (Pl. VII., A, 5.)

The epithelial cells appear cloudy, are somewhat swollen, and show very seldom a sharply defined separating border. Often their swelling has so far advanced that they appear more like a homogeneous finely granulated mass, in which the nuclei alone, separated from each other by regular distances, allow them to be recognized as epithelial cells.

Among the epithelial cylinders there are some in which the coagulated interior bulges through the covering of epithelium; in others the central exudate projects at the ends.

6. *The uric-acid cylinders* are distinguished by their characteristic composition, and they are only enumerated with the other on account of their form and place of origin. The uric-acid cylinders occur in the urine of nurslings who suffer from uric-acid infarction of the kidney. As in the urine, so also in the wash of the child we observe small red forms, which under the microscope are recognized as cylinders, made up of small granules of the urates, and not, as their name would denote, of pure uric acid. They are brown-red, show distinctly a coarsely granulated structure, and vary greatly as to size. (Pl. VII., A, 6.) If treated with KOH, ammonia is set free and the cylinders disappear. Besides the perfect cylinders, we find fragments.

7. *Cylinders of bacteria and micrococci* appear only with interstitial suppurative nephritis, and here also only in those cases where the disease is complicated with bacterian embolism of the urinary canals (*nephritis parasitica*, Klebs). We find these cylinders of the shape and size of the firm fibrine cylinders. They arise from the same place, the tubules of Bellini. We often find these forked, when they correspond to the junction of two straight tubes. They consist throughout of bacteria and micrococci. Since the bacteria are in a state of rest, these cylinders resemble the coarse-grained granular cylinders; these latter, however, are much smaller and more delicate. By applying a high power of the microscope, confusion is not easily possible.

Under the above-mentioned forms the reader will miss some which have been described in other books, but which we ourselves have had no opportunity of observing; and we conclude that, if such forms do occur, it is only very rarely. The cylinders of pus-cells must not be confounded with the short plugs of purulent matter which arise from the papillary part of the kidney and are characteristic of chronic pyelitis. Further, we mention cylinders of calcium oxalate and also cylinders with imbedded uric-acid crystals. It often happens that to the cylinders crystals of uric acid and oxalate of calcium become attached. They do not appear imbedded in the cylinder mass, but added after it has left the urinary tubules as an accidental attachment.

6. *Fungi.*

In the urine a number of parasitical growths may exist, some of which are of frequent occurrence, while others appear more accidentally.

The most frequent forms which one has the opportunity of observing are the following: 1. Bacteria; 2. Yeast fungi; 3. Sarcinæ; 4. Oïdium lactis; 5. Differently developed spores and fragments of *penicillium glaucum.* Some forms occur oftener in alkaline and others in acid urine.

1. *Bacteria,* predominantly inhabitants of alkaline urine, described by some authors as a low form of animal life, by others as a plant, being spoken of synonymously as *Vibriones, Monades crepusculæ, Microzymæ,*

etc. At present it appears probable that they belong to the fungi and are grouped under Nägeli's *Schyzomycetes.* They are very different in their appearance, and from a practical standpoint, according to A. Vogel, they have received various names. It is only necessary to remember that they are fungi.

A urine which contains an appreciable amount of bacteria appears always cloudy. After a long time part falls as a sediment to the bottom without the fluid becoming clear. According to A. Vogel, the following forms are to be distinguished:

a. The monad forms. These are round punctiform bacteria, which either remain quiet or show a quivering motion. One must exercise care not to confound with these the earthy phosphates which have a molecular movement. While the movement of a dead organism goes on in one place, the monad forms of bacteria change their position in the field.

b. The rod forms. These are very small rods, scarcely the diameter of a blood-corpuscle, and immeasurable in thickness. Both ends are generally swollen and knob-formed. They are sometimes at rest and sometimes moving through the field.

c. The vibriones. These are made up of the above-mentioned forms—two or more rod-like bacteria hanging on to one another, moving sometimes spirally and sometimes with a motion resembling that of a fish's tail, going hither and thither with great rapidity.

d. Leptothrix, or chain forms. These are long, often reaching across the entire field, and are to be distinguished only by their length from the vibriones. Only with a very high magnifying power can their jointed composition be recognized. They move but seldom, and then very sluggishly, in the manner of a serpent.

e. The zoöglea forms. These appear as masses of punctiform bacteria held together in a common gelatinous mass, resembling a precipitate of earthy phosphates held in mucus.

All these forms may be observed in the same urine, and often under the same cover-glass.

2. *The yeast plants* (*Saccharomyces urinæ*).—These are single vesicular cells, of the size of blood-corpuscles, and of somewhat oval shape. Usually, however, they are made up of small cells arranged like a rosary, some of the beads having two or three bud-like cells attached. (Pl. VIII., A, 1.) This fungus appears in much less quantity than the bacteria, and is found mostly in acid urine on a warm day. This plant has the greatest similarity to the yeast plant of beer (*Saccharomyces cerevisiæ*), without being identical. In diabetic urine this form occurs, but more vigorously developed.

3. *Sarcinæ.*—This form has the greatest similarity to *Sarcina ventriculi*, but is appreciably smaller. They are arranged in groups of 2, 4, 8, etc., and the small cells are built up in cube form and present the appearance of a cross-bound bale of goods. (Pl. VIII., A, 3.)

The urine in which sarcinæ are found is chiefly alkaline, and in the sediment we find also calcium- and triple phosphate. The evacuation of sarcinæ lasts for weeks, sometimes for months.

4. *Oïdium lactis.*—This appears in the form of long cells, recognized by their granules being arranged at regular intervals. These occur not infrequently in the fermenting urine of diabetes.

5. *Penicillium glaucum.*—There may exist in the urine also spores of this plant. In great part these exist as germs, often as branching forms or reticulated fibers, covered with a coating of fine urates, appearing furry and brown-red. (Pl. VIII., A, 2.)

[6. The *Bacillus tuberculosis* has been found in urine, but precaution should be taken, as a form very closely resembling it has been found in the healthy urethra.]

The spores for the evolution of all the forms of fungi mentioned develop outside of the bladder. This rule, however, has exceptions. The sarcinæ are always excreted with the urine from the bladder. Sometimes this may be the case with bacteria, though this may be explained from the use of unclean sounds or catheters. Cases have come to our knowledge, though very rarely, where there was certainty of no instrument having been introduced previously into the bladder or urethra. It is very difficult to ascertain whether these forms of fungi have any influence on the reaction or fermentation of the urine. The small chain fungus appears not alone in alkaline urine, but in every case in which an albuminous substance becomes fetid or decomposed. We therefore find the same in the secretions of different ulcers, in ichor, and in cholera stools.

In this place we may mention in passing an indication which was formerly considered a characteristic sign of pregnancy. With the name kyesteine was christened that membrane which forms on the surface of long-standing urine, and which consists of an interlacing network in which calcium- and triple phosphates, bacteria, and sometimes also animal organisms, are imbedded. It forms, however, upon the urine of men, and has of late lost its significance.

7. *Spermatozoa.*

Spermatozoa appear with a strong power (Hartnack, III., 7 = × 330) as small rounded forms, with a longer or shorter hair-like tail. Seldom has one an opportunity of seeing them in motion in the urine. A urine which contains spermatozoa often shows white cloudy flakes, which under the microscope are resolved into a mass of spermatozoa imbedded in a finely granulated substance. Since spermatozoa are very light, they require several hours to settle. After six to twelve hours we find, besides the flocculent lumps, also isolated seminal granules. On account of the resisting capability of these structures, they may be found in the urine after several days. (Pl. VI., A, 3.)

We find spermatozoa—

1. After coition, nocturnal pollution, etc., when a part of the semen remains behind in the urethra, and is washed out later by the urine.
2. With spermatorrhœa.

We also observe involuntary emissions in typhus.

In the urine of women we find spermatozoa after coition—a fact which may have great medico-legal importance.

8. *Cancer Elements.*

Two different forms of cancer elements are observed, though quite seldom: *a.* Isolated cancer-cells; *b.* Pieces of cancer-tissue.

a. The cancer-cells are variously (Pl. VIII., B, 1) and often quite oddly formed. They are large and for the most part caudate cells, with a very large and often more than one nucleus. Sometimes we observe the so-called vacuoles. Care must be taken not to regard the caudate cells of epithelium which come from the kidney-pelvis as cancer-cells. The cancer-cells correspond to the epithelial covering of a cancerous growth, and generally arise in the bladder. Only from an abundant appearance of these peculiar and many-formed cells can we with certainty recognize a malignant growth.

b. Fragments of villous cancer (Pl. VIII., B, 2) may occur in various forms in the urine sediment. We either find the same well preserved, when we are able to distinguish the papillary growth under the microscope (it seldom appears in this condition), or on the other hand it may be necrotic, when the diagnosis is attended with considerable difficulty. The well-preserved cancerous tissue, under a magnifying power of 300 diameters, exhibits in its finest branches a characteristic tree-like formation, similar to fringe, which consists of a widened blood-vessel (Hohlkolben) covered with a single layer of epithelium. It is seldom that such a beautifully formed tree can be seen under the microscope. Usually sloughed off and much altered pieces of tissue only appear in the sediment, and the identification of these is very difficult. In the tree form the epithelium has generally undergone molecular disintegration, and is accompanied with bacteria; the villus itself is infiltrated with pus-corpuscles. In this molecular detritus, chiefly consisting of small flakes, we occasionally find forms which materially assist the diagnosis of villous tumor.

Often, if we treat the necrotic cancerous tissue with glycerine, and sometimes when we have not done this, we observe beautiful crystals of hæmatoidine. They appear of a brown-yellow color, either in beautifully built small rhomboids or in small, yellow, grassy tufts. Such cancerous tissues, treated with fuming nitric acid under the microscope, show by the well-known rainbow play of colors the reaction of the biliary coloring matters. Hæmatoidine is recognized in old blood-extravasations, but in the urinary sediment it is never observed except as isolated crystals. If, however, we find these crystals imbedded in necrotic tissue, then is the diagnosis of old hæmorrhagic and necrotic tissue assured. This condition has up to this time been found only with villous tumors. Hæmatoidine villus occurs only in acid urine.

There is yet another sort of crystal which has also been observed by us only in necrotic villous tissue, which appears only in acid urine, and may also serve as an index for the diagnosis. These are small, colorless, crossed, aggregated leafy crystals, in dumb-bell form, which sometimes take on a spherical shape. These are a very rare form of calcium oxalate.

Sometimes with a low magnifying power (120) we observe thicker and darker-colored, tube-shaped, branching forms in necrotic flakes. These are small vessels which are to be seen in necrotic tissue.

If the urine is strongly alkaline, we find the villous tissue so changed and incrusted with phosphates, that a diagnosis of it can scarcely be made. One investigation of the urine in these cases is hardly sufficient for a diagnosis.

9. *Entozoa.*

We have not up to this time had an opportunity of observing entozoa, or even fragments of them, in the urine. According to the claims of other authors, the hooks of echinococci occur. We have, however, observed single hooks, as also a fragment of the sac of the echinococcus with the adhering animal forms, in the aspirated fluid of a kidney-tumor (Pl. VIII., A, 4); and it is possible that by rupture of the same into the pelvis of the kidney the hooks might appear in the evacuated urine.

In the tropics hæmaturia caused by entozoa is observed. Under this head the most important form of entozoa is the *Distoma hæmatobium* or *Bilharzia hæmatobia.* It penetrates most probably from the intestinal tract into the plexus venosus prostaticus, and there lays its eggs. These have an oval form, and on one end is to be seen a short point. They stop up the small vessels of the mucous membrane of the bladder; then there arises a bladder-catarrh with hæmorrhage, and the eggs become excreted in the urine. In the urinary sediment we find small flakes in such cases, in which under the microscope, besides numerous blood- and pus-corpuscles, are imbedded a great number of the eggs of *Bilharzia hæmatobia.**

[The adult parasite is a trematode. The male rarely exceeds one third of an inch in length, and is shorter and broader than the female, which is more filiform, and may attain to the length of three quarters of an inch. They bear two suckers, and the male a long canal in its upper half, in which the female is partially inserted during copulation. The ova are about $\frac{1}{200}$ inch long and $\frac{1}{600}$ inch broad, and are characterized by a spine at the anterior part of the capsule. It is by the appearance of these in the urine that the cause of the hæmorrhage is to be diagnosticated. The cases in which it occurs in America seem to have contracted the disease in Africa. Belfield † records such a case.

The *Strongylus gigas*, a nematoid worm found in the kidney-pelvis of dogs, wolves, horses, oxen, and some other animals, has been very rarely found in the human kidney. It resembles the ascaris lumbricoides, but has six instead of three papillæ around the mouth, and is larger, the male reaching a foot in length and one quarter of an inch in breadth, and the female a yard in length. It may occur in the urine through its ova, or in adult form; and when present in the renal passages may give rise to colic hæmaturia and pyuria.*

---

* We have to thank Dr. Sachs, of Cairo, for some very beautiful preparations of the natural sediment of endemic hæmaturia.

[† "Diseases of the Urinary Organs," p. 154.]

The *Pentastoma denticulatum*, found under the capsule of the liver of herbivorous animals and man, was once found by Wagner under the capsule of the right kidney of a man dead from Bright's disease. Inasmuch as it has never been found in the urine in any form, it does not deserve further mention in this treatise.

The *Filaria sanguinis hominis* seu *Bancrofti*, as the probable cause of tropical chyluria and sometimes hæmaturia, is a matter of interest to American and English physicians, since several cases of its importation from the tropics have been brought to notice. The form usually seen is the embryonic. The embryos are long, snake-like, transparent, and apparently structureless, from $\frac{1}{92}$ to $\frac{1}{75}$ inch in length, and $\frac{1}{3153}$ inch in breadth. It is slightly tapering at the anterior extremity, and terminates at the end in a filamentous projection like the lash of a whip. Viewed through a magnifying power of six hundred diameters, transverse markings may be observed, but

---

[* The rhabdites genitalis, a nematoid, has recently been found in the urine of three persons. In one case (a woman) it seemed to come from the external genitalia. In the second case it seemed to be the cause of a paroxysmal hæmoglobinuria, and in the third of an intermittent hæmaturia. The two latter persons were children.]

no oval or anal openings. When drawn from fresh blood it wiggles quite actively. The embryos are found principally in the blood, and a few at times in the urine. Digestion and exercise cause its appearance in large numbers when present. The adult is a nematoid worm, and, according to Manson, inhabits the lymphatics (the two sexes living together), where it causes a blocking up of the lymph-vessel, with consequent rupture and chyluria.]

It is hardly necessary to give a further description of accidental entozoa which have been found in the urine, but which have no especial significance.

Bits of feather dusters, of wood fibre, of dried plant-tissue, as tobacco leaf, dust, and cotton and woolen fibres, are found in the urine. Besides this, it is hardly necessary to advise care as to cleanliness of the cover-glasses.

ADDENDA.

CONCRETIONS.

By urinary concretions we understand the hard, stony formations, which are sometimes made up of normal and at others of abnormal constituents.

The size of these differs greatly. We find urinary concretions the size of the fist and larger, while some can only be recognized by the microscope.

Every concrement, great or small, must allow the recognition of an arrangement of its molecules in layers, and have a more or less rounded form. A single exception to this rule is the cystine stone, which upon cross-section shows a crystalline leafy formation rather than layers.

If we wish to determine the nature of the urine concretions, we must employ the aid of a lens or microscope.

Often we find such small concretions of uric acid that with the unaided eye they may often be mistaken for the crystals of uric acid (the rosette). Just so with small concretions of calcium carbonate, which show distinctly their laminations with a lens of 100 to 200 diameters.

The small concretions come usually from the kidneys, the larger from the bladder.

The stones are formed either of one constituent or of different stone-forming elements arranged in layers (eccentrically). The uric-acid stones consist, as a general rule, entirely of uric acid or its salts; the cystine stone only of cystine; while the oxalates have generally a kernel of uric acid and an outer phosphatic layer. The phosphatic stones possess uric-acid centres.

Whether these urinary concretions are formed of but one or several constituents can in every case be distinguished.

The best means of determining the constituents of the concretionary layers is to saw the stone in two halves with a bow or jeweler's saw.

The innermost layer of the cut surface is the kernel; this is from the size of a millet-seed to that of a pea or larger, and is contrasted better with the surrounding matter if the next layer is of another color.

The kernel is the most important part of every stone. It alone explains to us the cause which has brought about the formation. If we find a uric-acid kernel in a phosphatic stone, we know that the primary condition which influenced the stone formation was due to uric acid. If the kernel happens to be a fragment of a bougie or a foreign body in the centre of a phosphatic stone, we must recognize the agency of the foreign body in producing the stone.

From a practical or surgical standpoint, stones are classified according to their chief constituents. Thus we distinguish stones of urates, oxalates, phosphates, and cystine. This classification has a practical importance which is not to be underestimated; for if the surgeon diagnoses a stone as phosphatic, he may conclude that it is a case for the lithotrite; if formed of oxalates or urates, he may conclude that the stone is very hard.

There are frequently stones which exhibit three or more stone-forming constituents in their layers. It is more convenient to classify such stones in two groups, according to the character of their kernels. The first group includes such stones as are formed by the sediment of acid urine. The second group includes those stones the kernels of which are formed by foreign bodies, by blood-coagula, or from the constituents of alkaline urine.

This classification conforms precisely to what we have designated as primary and secondary stone formation. The primary formation is the building of a kernel out of the sedimentary constituents of acid urine. The secondary formation is only an incrustation of a foreign body or of a kidney-stone arrested in the bladder.

The primary stone formation occurs only in the kidney; the secondary mostly in the bladder.

A peculiar class is formed by the so-called "metamorphosed" stones, which consist of earthy phosphates, and form a quite homogeneous and very porous mass. They are always the product of a chronic suppuration which has lasted many years; the sediment of acid urine being dissolved by the alkaline pus, the earthy phosphates are substituted.

The primary stone formation is as a rule caused by uric acid, since bladder-stones for the most part have a kernel of that substance.

In the investigation by Ultzmann of 545 bladder-stones, the kernels were found to be composed as follows:

Kernels of uric acid . .	441 =	80·92	per cent.
" of calcium oxalate .	31 =	5·69	"
" of earthy phosphates .	47 =	8·62	"
" of cystine . . .	8 =	1·47	"
Foreign bodies as kernels . .	18 =	3·3	"

Analysis of the Concretions.

Every large concretion must first be cut in two by means of a fine saw. The collected sawdust is well mixed, and should be investigated by the methods given below. By these methods we are enabled, by their characteristic reactions, to ascertain the principal constituent, and also to detect the various elements which compose the layers, but not to say in what order the layers occur. To find the arrangement of the layers, it is necessary to polish the smoothly sawed surface of the half, by rubbing for some time on a ground glass plate, when the different layers of the stone become distinctly visible. After dusting with a cloth, we may easily scrape as much powder from each layer by means of a pen-knife as will suffice for the test. In this way every urinary concretion may be accurately analyzed. Perhaps an example may be advantageously given.

If a bladder-stone has been sawed in half, and by the analysis of the dust we have found that two thirds of the stone consists of incombustible (inorganic) and one third of combustible (organic) constituents; and also if we have proved the presence of uric acid, oxalic acid, phosphoric acid, carbonic acid, calcium, magnesium, and ammonium; furthermore, if we have polished the sawed surface of the stone, and recognize three distinctly separated and differently colored layers by means of the unaided eye, and find in the centre a kernel the size of a pea, which by analysis is found to consist only of uric acid, the dark-brown middle layer to consist only of calcium oxalate, and the outer white layer to be made up of the phosphates of calcium and magnesium, the complete analysis should be proceeded with as follows:

Analysis.—Take several milligrammes of stone-powder and heat it carefully on a piece of platinum foil.

After intense heating, observe whether the powder is entirely consumed, or whether a residue remains; further, whether the powder is consumed with a visible flame, whether it decrepitates (oxalate of lime), or whether it gives off a characteristic odor.

I. If the powder is entirely consumed by heat, the following stone constituents may be present: Uric acid, urates of sodium and ammonium, xanthine, proteine, and cystine.

(1.) *Proteine* (fibrine) burns at a red heat with a brilliant yellow flame, and diffuses a strong odor of burning feathers or hair.

(2.) *Cystine* burns with a weak bluish-white flame, and gives off a penetrating smell like burning fat and sulphur. The powder is dissolved in dilute ammonia, and shows under the microscope, upon evaporation of the same, beautiful hexagonal plates.

(3.) *Xanthine* by the murexide test shows an orange-yellow color, and burns without a visible flame.

(4.) *Uric acid* and *sodium and ammonium urates* burn without visible flame, and give with ammonia a beautiful red, and with KOH a beautiful violet murexide.

a. The urate of sodium is distinguished from the urate of ammonium, and from free uric acid, by the fact that on the foil upon which it has been heated there remains a light cloudiness. If a piece of red litmus paper is moistened with distilled water and laid upon this cloudy spot, a similar blue spot appears on the paper. This is caused by the sodium carbonate (or caustic soda) which has been formed by heating the urate of sodium. The urate of ammonium and the free uric acid do not give this test.

b. The urate of ammonium is distinguished from the free uric acid by the so-called cold ammonia test. This is accomplished as follows: Take a small test-glass, and to 0·1–0·2 gramme of the powder to be tested add a few drops of a concentrated solution of KOH. This glass is then covered by a watch-glass which has on the convex surface a small piece of wet red litmus paper; if after a few minutes the paper becomes blue, ammonia is present.

c. Free uric acid gives naturally a negative result with the litmus test.

II. If the powder is partially consumed, or is unaltered by heat, the stone consists essentially of calcium and magnesium salts. Then the following constituents may be present: Calcium oxalate, calcium carbonate, calcium phosphate, and ammonio-magnesium phosphate.

(1.) *Calcium oxalate* does not effervesce upon the addition of a drop of HCl. By intense heat this powder shows a peculiar glow and decrepitates slightly. The oxalate of calcium is by this means transformed into the carbonate of calcium; and if now a drop of HCl is added there ensues a brisk effervescence.

(2.) *Calcium carbonate* effervesces upon addition of HCl without first heating. (By this it is distinguished from the oxalate.)

(3.) *Calcium phosphates* and the *ammonio-magnesium phosphate* do not effervesce upon the addition of a drop of HCl, either before or after incineration. (By this they are distinguished from the carbonate and oxalate.) The incinerated powder is readily soluble in HCl. If we add to this solution ammonium hydrate [$(NH_4)OH$] drop by drop until the solution has become alkaline, there appears a white flocculent precipitate, which consists of the amorphous basic calcium phosphate and the crystalline ammonio-magnesium phosphate. Under the microscope the triple phosphate appears in stars or oblique crosses, while the calcium phosphate appears amorphous. Accordingly, from this precipitate we may conclude whether the calcium or the ammonio-magnesium phosphate is predominant by the relative amounts of the amorphous and crystalline precipitates.

CHAPTER IV.

REAGENTS AND APPARATUS FOR THE APPROXIMATIVE DETERMINATION OF THE CONSTITUENTS OF THE URINE.

REAGENTS.

SINCE the physician generally procures his reagents from the apothecary, for the sake of convenience we give the prescription formulæ. For these reactions it is best to employ glass-stoppered bottles with wide necks, with a capacity of 250 c.c.

A. Acids.

1. Acid hydrochloric, concent., c. p., 200 grms.
2. Acid sulphuric, concent., c. p., 200 grms.
3. Acid nitric, concent., c. p., 200 grms.
4. Acid acetic, concent., c. p., 200 grms.

B. Bases and Salts.

5. Potass. caust., alcohol dep., 100 grms.
   Aqua dest., 200 grms.
6. Ammon., c. pur., liquid, 100 grms.

7. Barii chlorid. cryst., 30 grms.
   Aqua dest., 200 grms.
   Acidi hydrochlor., 10 grms.
8. Plumb. acet. cryst., 30 grms.
   Aqua dest., 200 grms.
9. Cupri sulphat., 30 grms.
   Aqua dest., 200 grms.
10. Magnes. sulphat., Sal ammoniac, depurat., } āā 30 grms.
    Aqua dest., 200 grms.
    Ammon. c. pur., liquid, 50 grms.
11. Argent. nitrat., 5 grms.
    Aqua dest., 40 grms.

For the latter reagents a pipette is advantageous.

12. Red and blue litmus paper in strips.

Besides these necessary reagents, the following may be employed for special cases: Distilled water, ferric chloride, basic acetate of lead, mercuric nitrate, basic nitrate of bismuth (magist. bismuthi), fuming nitric acid, potassium nitrite, starch, chloroform, ether, alcohol, iodine in iodide of potassium solution, acetic acid, sodium chloride, and zinc chloride.

APPARATUS.

1. Six test-tubes, with rack.
2. Ten wine-glasses or small test-glasses.
3. Cylinder glasses of 100, 200, and 300 c.c. capacity.

4. A graduated glass.
5. A 100 c.c. flask, with a glass tube through the cork.
6. A wash-bottle for distilled water.
7. A urinometer.
8. A spirit lamp.
9. Two small porcelain evaporating dishes.
10. A ring stand with two rings.
11. Filter paper.
12. Four glass funnels for filtering.
13. Glass rods.
14. A microscope with appurtenances.
15. A large beaker of 3,000 to 4,000 c.c. capacity.

For special cases we must have watch-glasses, beaker-glasses, and pipettes; and for quantitative examination, a delicate pair of scales.

P. H. Watters, M.D.

CHAPTER V.

QUANTITATIVE DETERMINATION OF A FEW OF THE CONSTITUENTS OF THE URINE.

As a first step toward the quantitative investigation, the entire mass of the excreted urine must be collected for a given time. Usually the amount for twenty-four hours is collected, but it must be observed that before a stool one should urinate, that none be lost by being mixed with the fæces. It is inadmissible to attempt to determine the amount for twenty-four hours from the quantity collected in one hour (p. 36).

The urine should be collected in graduated cylinders. For large amounts one may graduate a vessel himself. Take a flask containing 1 litre of water at 15° C., and pour into the cylinder to be graduated, making a mark on the glass at the surface of the fluid, repeating this as often as necessary.

If one desires to ascertain the mean amount of the urine excreted by an individual, the total amount should be collected for several days, and the quantity be divided by the number of days.

I. ESTIMATION OF THE DEGREE OF ACIDITY.

In order to ascertain the degree of acidity of the urine, we add Na OH to the same until it reaches the point of neutralization, and then compute how much acid (we usually employ oxalic) is required to neutralize the quantity of sodium hydrate used.

a. Volumetric Solution.

P. K. Walters, M.D.

We employ a one-tenth Na OH solution, which in 1 c.c. contains 0·0031 grm. Na_2O, which is sufficient to neutralize 0·0063 grm. of crystallized oxalic acid. If we employ normal sodium hydrate, we add 10 times its volume of distilled water. (Description of normal sodium hydrate, Mohr, "Titrirmethode," 4th edition, p. 83.)

b. Example.

We pour exactly 100 c.c. of urine into a beaker-glass, and add while stirring the sodium-hydrate solution drop by drop from a burette, until a drop of the urine on red litmus paper shows no blue and on blue litmus paper no red spot. The number of c.c. of NaOH solution added (say 14) we multiply by 0·0063, and the product (0·0882 grm.) shows the acidity of 100 c.c. of urine expressed in crystallized oxalic acid.

II. ESTIMATION OF THE SOLID MATTERS.

In order to estimate the solid matters, we take 10 c.c. of urine in a weighed porcelain dish, and evaporate on a water-bath to dryness. It should then be kept for an hour in a drying chamber at 100°, and then allowed to cool in a desiccator. We now weigh and replace the dish in the drying chamber, weighing again at the expiration of an hour after cooling as before, repeating this until there is no variation in weight. The difference of weight between the empty dish and that containing the solids is the weight of the solid matters in 10 c.c. of the urine. Unfortunately the result is always too small, for the action of the acid sodium phosphate on the urea at this temperature decomposes the latter, and ammonia and carbonic acid are driven off at the same time with the water.

It is seldom that the physician employs this means for the investigation of the amount of solids, for by using Häser's or Trapp's coefficients as satisfactory results are obtained, at least for him. (See p. 39.)

III. ESTIMATION OF UREA.

Liebig's Method.

a. Reagents.

1. *Baryta solution.*—One volume of a cold saturated solution of barium nitrate is mixed with two volumes of a cold saturated barium hydrate solution.

2. *Volumetric mercuric reagent.*—This is a solution of mercuric nitrate (in which there must be no basic salt or mercurous compound), of such concentration that in 1,000 c.c. of the solution 71·48 grms. of pure mercury

or 77·2 grms. of pure mercuric oxide (dried at 100°) are contained. See Neubauer and Vogel, l. c., 183; Mohr, l. c., 48, 1.)

3. *Sodium carbonate solution.*—For Raudenberg's modification we employ sodium-hydrogen carbonate.

b. Method of Procedure.

We take up 40 c.c. of urine in a pipette, and add 20 c.c. of the baryta solution. Here, as in all other cases of quantitative work, the greatest care must be exercised. In the pipette there should be no foam, and one should read the division mark on the pipette which corresponds to the lower edge of the meniscus. We must be especially careful that none of the fluid be lost. If we have treated the urine with the baryta solution, the precipitate of phosphates and sulphates which has separated should after some time be filtered off, using a dry filter-paper and allowing the fluid to run through into a dry beaker. The filtrate is therefore one third baryta solution and two thirds urine from which the sulphates and phosphates have been removed. We now take 15 c.c. of this clear fluid by using a pipette, and allow it to flow into a dry glass vessel. This contains 10 c.c. of urine. Now, from a burette filled precisely to the zero point with the mercuric nitrate mixture, we add about as many cubic centimetres of the mixture as are denoted by the last two figures of the specific gravity of the urine (i. e., 15 c.c. if the specific gravity is 1·015), and try whether the limit has been reached. For this purpose we place a drop of the well-stirred mixture by means of a clean glass rod on a glazed white porcelain plate, and in the centre of this drop add a small drop of a concentrated solution of sodium carbonate. If there occurs at the rim of contact of the fluids no rusty brown zone, we proceed to add more of the mercuric nitrate solution. If, however, even a faint rusty brown ring occurs, we know that the limit has been reached.

The first effect of the addition of the mercuric nitrate is an exchange of bases with the alkaline chlorides present, forming $Hg\ Cl_2$ (corrosive sublimate) and an alkaline nitrate. The chlorides having been thus disposed of, the excess of mercuric nitrate combines with the urea, forming $2CO\ H_4\ N_2,\ N_2\ O_5,\ 4HgO$, which is a white precipitate. This precipitate dissolves to some extent in a slight excess of acid, from which it may be brought down *white* by rendering the solution neutral, on adding sodic carbonate. As soon, however, as the urea is all satisfied, a further addition of the mercuric compound remains in the solution, and then gives a yellowish or brownish precipitate of basic mercury salt on neutralizing with the sodic carbonate, and the end of the reaction is indicated. Since the presence of chlorides deprives the mercuric nitrate of its power to precipitate the urea, the determination is inaccurate in so far as chlorides are present. For that reason the mercury solution is made a little stronger than the theory requires. If the urine contains 1 to 1½ per cent. of sodium chloride, 2 c.c. of the mercury solution must be subtracted from the amount used to give approximately accurate results, assuming that 15 c.c. of the urine is used.* The property which the chlorides possess of destroying the precipitating power of mercuric nitrate upon the urea may be used to determine the amount of chlorides present.†

When the mercuric-nitrate solution has been added in sufficient quantity, we allow the burette to stand for several minutes, and then read off how many cubic centimetres had been used.

The reagent is so compounded that 1 c.c. of the solution satisfies 10 milligrammes of urea. If we have employed 20 c.c. of the reagent, then is 1 c.c. : 10 milligr. : : 20 c.c. : x (= 200 milligr.). Consequently, if we have used 20 c.c. of the mercuric reagent, then must 200 milligr. of urea have been present, which has entered into combination with the mercury. This was contained in the 15 c.c. of the urine and baryta mixture (which contained 10 c.c. of urine). We have therefore as a consequence:

In 10 c.c. of urine are 200 milligr. of urea; so in 1,250 c.c. (the amount for twenty-four hours) we have 10 : 200 : : 1250 : x (= 25,000 milligr. = 25 grms.).

1. Since the mercuric reagent is intended for a 2 per cent. urea solution, we only obtain exact results when to 15 c.c. of a 2 per cent. urea solution we add exactly 30 c.c. of the reagent; for 1 c.c. satisfies exactly 10 milligr. of urea.

Each c.c. of the reagent requires 72 milligr. of HgO, according to the computation, in order to combine with 10 milligr. of urea. In addition, however, a certain excess of HgO is necessary for the final reaction. According to Liebig's calculations, this amounts per c.c. to 5·2 milligr.; hence in 30 c.c. we have $30 \times 5{\cdot}2 = 156$ milligr. (excess of HgO). If we have added to 15 c.c. of the 2 per cent. urea solution 30 c.c. of the volumetric reagent, then the mass of the mixture consists of 45 c.c., which contains 156 milligr. of excess of HgO; that is to say, each c.c. contains $156 \div 45 = 3{\cdot}46$ milligr. Therefore for a distinct final reaction every c.c. of the mixture must contain 3·46 milligr. of HgO.

---

* Neubauer and Vogel, second edition, 1856, p. 106.

† Neubauer and Vogel, p. 94.

If 15 c.c. of the urea solution contains 3·5 per cent. of urea, this would require 52·5 c.c. of the volumetric mercuric reagent. The mixture consists of $15 + 52{\cdot}5 = 67{\cdot}5$ c.c. In the 52·5 c.c. of the volumetric reagent are $52{\cdot}5 \times 5{\cdot}2 = 273$ milligr. of excess of HgO; hence in every c.c. there are 4·04 milligr. The final reaction occurs, however, with 3·46 milligr. In this case we have consequently 0·58 milligr. per c.c. too much free HgO. Therefore the final reaction would occur sooner.

If, on the contrary, the solution contained but 1 per cent. of urea, we would have an error in the opposite direction.

In order to eliminate both errors we proceed as follows:

(*a*.) If more than 30 c.c. of the volumetric reagent have been employed, before the sodium carbonate test we must add one half as many c.c. of water, as the excess in c.c. of the volumetric mercuric reagent we have employed; i.e., having used 52·5 c.c. of the reagent, we add $\frac{52\cdot5-30}{2}=11$ c.c. of water to the mixture before the soda test.

(*b.*) If less than 30 c.c. of the fluid have been employed, for every 5 c.c. less than 30 we must deduct 0·1 c.c. from the amount used. For example, we have used 20 c.c. (10 c.c. less); consequently, we employ $20-0\cdot2=19\cdot8$ c.c. in the computation.

2. If the urine contains from 1 to 1·5 per cent. Na Cl, a greater quantity of the volumetric mercuric reagent is required. If without correction we estimate the urea, we find the quantity (15 to 25 milligr.) too great. In order to correct this error, we subtract 2 c.c. from the amount of the volumetric mercuric reagent used. For example, if we have employed 30 c.c. of the reagent, $30-2=28$ c.c. must be used in the computation of urea.

If the absolute amount of urea alone concerns us, without considering it relatively, we must either precipitate the Na Cl by means of a nitrate of silver solution or by Rautenberg's method. For this we take two samples of urine 15 c.c. each, and render one weakly acid with HNO_3. We then drop in the volumetric mercuric reagent until a permanent turbidity ensues. Then we note the number of c.c. we have employed, and then with the other sample make a determination of the amount of urea after Liebig's method. The mixture, however, must be made neutral by addition of freshly precipitated calcium carbonate. For the final reaction we employ, instead of the soda solution, sodium-hydrogen carbonate in water (see p. 203). From the number of c.c. we have employed in the last test we subtract the number used in first sample, and from their difference we estimate the urea. If in the first sample we used 1·5 c.c. and in the second 31 c.c., we then employ in the determination $31 - 1{\cdot}5 = 29{\cdot}5$ c.c.

3. If albumen is present in the urine, a stoppered flask of 200 c.c. capacity should be employed, and the urine after the addition of a few drops of acetic acid should be heated until the albumen has separated in flakes from the clear urine. After closing the flask and allowing it to cool, the filtrate should be used in the usual manner.

2. *Bunsen's Method* (Bunge).

This is only applicable to urines free from albumen and sugar. By it 50 c.c. of urine are treated with 25 c.c. of a saturated ammoniacal barium-chloride solution, and filtered through a thick filter-paper; then 15 c.c. of the mixture (containing 10 c.c. of urine) are poured into a thick-walled tube so that the sides are not sprinkled by the mixture. At the bottom of the closed tube have been placed about 3 grms. of crystallized chloride of barium. After the urine has been added, the tube should be sealed about three fingers above the fluid. The tube is now placed in an oil-bath and heated for six hours at a temperature of 220° to 240°. After cooling, the point of the tube is broken off, and the resulting barium carbonate is placed upon a filter and carefully washed, then dissolved in a proper amount of HCl.

Should some of the barium carbonate, after the washing of the tube with water, still adhere to the sides, it should be dissolved by a drop or two of HCl. The united solutions are then filtered, and the filtrate is precipitated with H_2SO_4. After some time the precipitated barium sulphate is collected on a filter, washed, heated to redness, and weighed.

Since 233 grms. of barium sulphate correspond to 60 grms. of urea, the weight of the urea may be estimated by a simple calculation.

3. *Knop–Hüfner's Method.*

a. Reagents.

1. Knop's fluid (hypobromite of sodium). In 250 c.c. of water 100 grms. of caustic soda are dissolved, and after cooling 25 c.c. of bromine are added. This should be freshly prepared.
2. Cold saturated chloride of sodium solution.

b. Mode of Procedure.

The lower bulb and stopcock of Hüfner's apparatus (the capacity having been accurately determined) are filled with a mixture of 10 c.c. of urine diluted with 40 c.c. of water. The cock is then closed, no bubbles being allowed to remain. The second and larger bulb, connected by means of the stopcock with the lower bulb and opening above into the basin, is now washed with water and filled with Knop's fluid, diluted with an equal volume of water. The basin is then sufficiently filled with the sodium-chloride solution, and the eudiometer filled with water is inverted, the mouth below the surface of the sodium chloride solution in the basin, and placed over the narrowed neck of the second bulb, being retained in this position by the clamp above. The stopcock is then turned, and for a few minutes a violent evolution of gas is observed. After an hour the eudiometer may be withdrawn and the amount of the contained nitrogen estimated by Dumas's method. One gramme of urea furnishes 370 c.c. of nitrogen, at 0° C. and under 760 mm. pressure.

[A description of a ureometer devised for the rapid estimation of urea, by Prof. Charles Doremus, which is the simplest and most reliable method for approximative tests, is given in the "Journal of the American Chemical Society," Vol. VII., No. 3, 1885, and also in the "New York Medical Record," Vol. XXVII., No. 11, p. 307.]

IV. DETERMINATION OF URIC ACID.

To 300 c.c. of urine are added 10 c.c. of HCl; the mixture is stirred briskly with a glass rod and allowed to stand forty-eight hours in a cool place. If the urine contains albumen, it should be removed by the method given on p. 208. If it contains sugar, 500 c.c. should be treated with mercuric acetate, and the precipitate washed upon the filter, then suspended in a little water and treated with hydrogen sulphide. The mercuric sulphide is then washed with warm water, and the united wash-waters and filtrate treated with HCl.

The separated uric-acid crystals should be collected on a weighed filter-paper which has been washed with HCl and water and dried between two watch-glasses at a temperature of 100° C.

By collecting the uric acid the work is essentially lightened. The crystals lie mostly on the bottom of the glass; a part, however, adhere to the walls, and a few of the smallest float on the surface. Since the uric-acid crystals have a high specific gravity, they precipitate very quickly (after one to two minutes). Those clinging on the side walls may be disturbed by means of a goose-feather clipped except at the end. The disengaged crystals settle very quickly, so that one may easily decant the clear fluid above into another cylinder, and bring the remaining fluid and the precipitate upon a small filter. Should any of the crystals go over with the decanted fluid, they quickly settle, and may be saved and brought upon the filter by decanting again. We decant in this way until no more crystals remain in the urine. If the crystals are very small, recourse must be had to filtration.

The crystals are then washed with water until Ag NO_3 no longer renders the filtrate cloudy. It is a good precaution not to employ more than 30 c.c. of water; otherwise some of the uric acid will be dissolved. If more than 30 c.c. is used, for each c.c. one must add 0·045 milligr. to the amount of uric acid determined.

P. K. W.

When the uric acid has been washed, it should be dried for several hours between watch-glasses at 100° C., then cooled in a desiccator and weighed.

The difference between the weight of the watch-glasses when empty and when containing the uric acid gives the weight of the uric acid contained in 300 c.c. of urine.

Schwanert recommends as a correction, for every 100 c.c. of urine, 0·0048 grm. to be added.

V. DETERMINATION OF CREATININE.

a. Reagents.

1. Chloride of zinc solution. Pure zinc oxide is dissolved in pure HCl, and the solution evaporated on a water-bath (until no free HCl is present) to a thick sirup. This is dissolved in strong alcohol, and the solution diluted until it has a specific gravity = 1·200.
2. Milk of lime, which is stirred up before using.
3. Diluted chloride of calcium solution.

b. Mode of Procedure.

We render 200 c.c. of urine alkaline with milk of lime, and add diluted chloride of calcium solution as long as a precipitate forms. After two hours we filter and wash the residue, then quickly evaporate the wash-water and filtrate on a water-bath to a thick sirup. While it is yet warm, 50 c.c. of 95 per cent. alcohol are added to the mixture, and the same is transferred to a beaker-glass—washing the dish with a little alcohol—

and allowed to stand for eight hours. Then the mixture is filtered through a small filter and the residue washed with more alcohol. The united filtrates are then evaporated down to 60 c.c. After cooling, ½ c.c. of the above-mentioned chloride of zinc solution is added, and the mixture stirred briskly with a glass rod until turbidity occurs. It is then allowed to stand forty-eight hours in a cool place. We now collect the separated creatinine chloride of zinc on a small filter, and weigh after washing (as by the described method for uric acid). In 100 parts of creatinine chloride of zinc are 62·44 parts of creatinine.

VI. DETERMINATION OF THE TOTAL AMOUNT OF NITROGEN.

The chief amount of nitrogen in the urine is contained in the urea, and since, in Liebig's method for the separation of the same, other bodies containing nitrogen fall in connection with the urea, so in the greater number of observations the amount of nitrogen present may be calculated approximatively from Liebig's determination of urea.

a. Reagents.

1. Freshly calcined soda-lime.
2. Normal sulphuric acid, which contains 40 grms. of anhydrous acid in every litre. Each c.c. corresponds to 0·014 grm. of nitrogen. ("Darstellung," Neubauer and Vogel, l. c., p. 246; Mohr, l. c., p. 74.)
3. Sodium hydrate, which is an equivalent of the

H_2SO_4; i. e., 10 c.c. of the one must exactly neutralize 10 c.c. of the other.

4. Tincture of litmus.

b. Mode of Procedure.

Pour 20 c.c. of normal H_2SO_4 carefully into a Varrentrapp and Wills' nitrogen bulb apparatus. In a strong flask of 100 c.c. capacity, containing a layer of soda-lime 2 c.c. thick, is poured 5 c.c. of urine, and the flask quickly closed with a double-perforated stopper and buried to the neck in a sand-bath. Through one of the perforations a tube leads to the nitrogen apparatus, and the other is supplied with a finely drawn-out sealed glass tube. The sand-bath is heated as long as bubbles pass through the nitrogen apparatus. When these cease the end of the glass tube is broken off, and all the ammonia is drawn from the flask by careful aspiration. Now pour the contents of the nitrogen apparatus into a beaker-glass, wash well with water, add a few drops of litmus tincture, and then add the sodium-hydrate solution from a burette until the red color changes to blue.

If no ammonia had been generated by the distillation of the urine, 20 c.c. of the sodium hydrate would have to be added to neutralize the 20 c.c. of H_2SO_4. If 14 c.c. is however found to be sufficient, we know that 6 c.c. of H_2SO_4 have been satisfied by the ammonia formed. Since 1 c.c. of the acid corresponds to 0·014 grm. of nitrogen, then the total amount of nitrogen which has gone to form ammonia would be 6 × 0·014 = 0·084 grm. This would be given off by 5 c.c. of urine. Hence, if we had employed the whole amount of urine excreted in twenty-four hours (say 1,500 c.c.), we would have the amount indicated in the proportion 5 : 0·084 :: 1,500 : x, = 25·2 grms., which is the total amount of nitrogen excreted in twenty-four hours.

VII. DETERMINATION OF ALBUMEN.

Pour into a beaker-glass 100 c.c. of filtered urine if a slight amount of albumen is present, or 50 c.c. if a moderate amount is present, or 20 c.c. if rich in albumen. In the second case add 50 c.c., and in the last 80 c.c. of water, and heat for half an hour on a water-bath. Should the albumen not have separated in large flakes, then one or two drops of acetic acid should be added and the heat again applied. As soon as the fluid has become clear it should be filtered through a small plaited filter-paper which has been previously weighed (see uric acid determination, page 210), taking care that all the coagula should be brought upon the filter, if necessary by the aid of a feather, and the beaker washed with hot water. Then the coagulated albumen should be washed into the point of the filter, and further washed with hot water until chlorides can no longer be detected in the filtrate by the $AgNO_3$ test. Then dry between watch-glasses at 100° until no loss of weight is observed. The determination of the total amount excreted in twenty-four hours is easily calculated from this.

If one has a good polarizing apparatus, the amount of albumen may be easily determined, provided no sugar is present.

VIII. DETERMINATION OF SUGAR.

1. *Fehling's Method.*

a. Volumetric Solution.

Fehling's solution. In 1,000 c.c. there are 34·639 grms. of cupric sulphate, 173 grms. of pure crystalline tartrate of sodium and potassium, and 500 grms. of caustic soda solution of specific gravity 1·12. ("Darstellung," Neubauer and Vogel, l. c.; 206.) Of this solution 10 c.c. are reduced by 0·05 grm. of sugar.*

b. Mode of Procedure.

The determination depends upon the property that grape sugar possesses of reducing the cupric sulphate in the presence of an alkali. For this investigation a small amount of filtered urine is taken which has been largely diluted with water, unless it has previously been ascertained that only traces of sugar are present. Usually 10 c.c. of urine and 190 c.c. of water are employed. A burette is filled with this mixture exactly to the zero mark. Then 10 c.c. of Fehling's solution are poured

---

[* This fluid is best preserved by being put into small vials (20–30 c.c. capacity) and kept in the dark. Before using as a quantitative test a portion should be boiled, and if a precipitate occur the liquid should be freshly prepared. The liquid test is preferable to the pellets now on the market.]

into a flask or porcelain dish and diluted with 40 c.c. of water, then heated over a flame, having previously protected the flask with a piece of wire gauze. As soon as the copper solution begins to boil, the urine is added drop by drop from the burette. Soon the fluid becomes yellow, then red, and finally the last trace of the blue color disappears, and the red suboxide of copper rapidly subsides when the source of heat is removed. If allowed to stand for some time, the originally blue solution is seen to be colorless, or slightly yellow if more urine has been added than was necessary for the reduction of the copper. The entire loss of color of the fluid is consequently the limiting point of the reaction.

Since with the unaided eye it is not easy to determine when the fluid is colorless * and inclined not to any tint whatsoever, it is advantageous to pass a few drops of the fluid through a small filter and divide the filtrate into two parts, one of which after acidifying with acetic acid is tested for copper with ferrocyanide of potassium, and the other with Fehling's solution for sugar. If by this method we obtain no reaction for either copper or sugar, neither is present in excess, and consequently the limiting point of the reaction has been reached.

In the determination of the amount of sugar, the quantity of urine employed must be known. If 25 c.c.

[* Pavy has modified this test by the addition of ammonia to prevent the precipitation of the red oxide, which renders it difficult to distinguish the point of final reaction. For an account of his method, also called the "ammonio-cupric," see "London Lancet," March 1, 1884, p. 376.]

of the urine mixture were necessary to reduce 10 c.c. of Fehling's solution, the urine mixture being so made up that in 200 c.c. of it there were contained 10 c.c. of urine (the remainder water), then if $x =$ amount of urine in 25 c.c. of the urine mixture (the amount employed), we would have $200:10 :: 25:x = 1{\cdot}25$ c.c. of urine.

In this case 1·25 c.c. of the urine was necessary to reduce 10 c.c. of Fehling's solution. Now this solution is so constituted that for the complete reduction of 10 c.c. of the same it is necessary to have 50 milligr. of sugar. Since, however, 1·25 c.c. of the urine has effected this reduction, it is certain that this quantity must have contained 50 milligr. of grape sugar. Hence it is easy to calculate the sugar in the entire amount for the twenty-four hours.

If, for example, a diabetic patient had excreted 5,000 c.c. of urine, we would have 1·25 c.c. : 50 milligr. :: 5,000 c.c. : $x = 200{,}000$ milligr., or 200 grms. of sugar.

If albumen is present, it must be separated beforehand in the usual manner.

2. *Knapp's Method.*

a. Volumetric Solution.

Ten grms. of pure dried mercuric cyanide are dissolved in some water; 100 c.c. of sodium hydrate (specific gravity 1·145) are added, and the whole diluted to 1,000 c.c.; 40 c.c. of this solution are reduced by 100 milligr. of sugar.

b. Mode of Procedure.

Forty c.c. of the volumetric solution are heated in a beaker-glass, and urine added as in Fehling's method until the originally turbid mixture becomes clear and yellowish. From time to time a drop of this is thrown on a filter paper and touched with a rod dipped in ammonium sulphide. As soon as the spot no longer shows a brown edge, the reaction is complete. The method does not give quite as accurate results as Fehling's.

The fermentation method is more complicated and unreliable than Fehling's. Very exact results are obtained by Soleil-Ventzke's saccharimeter or Wild's polaristrobometer.*

IX. DETERMINATION OF CHLORINE.

1. *Mohr's Method.*

a. *Reagents.*

1. Cold saturated solution of neutral chromate of potassium.

2. Volumetric nitrate of silver solution, which contains in the litre 29·075 grms. of nitrate of silver (18·469 grms. Ag), so that 1 c.c. of the same corresponds to 10 milligr. of sodium chloride (= 6·065 milligr. chlorine). (Neubauer and Vogel, l. c., 194.)

3. Calcium carbonate, freshly prepared.

b. *Mode of Procedure.*

Ten c.c. of urine are poured into a platinum crucible, and 2 grms. of potassium nitrate free from chlorine are added, and the fluid evaporated on a water-bath to dryness. Heat the residue first gently, then intensely, over a Bunsen's burner, until the fused mass contains no carbon (is white). The slag is dissolved in water and the dish carefully washed. Solution and wash-water are put in a beaker and treated carefully with a much diluted nitric acid, free from chlorine, until the fluid possesses a weakly acid reaction, which is again neutralized by freshly precipitated calcium carbonate. Without regard to the sediment, three drops of the potassium-chromate solution are added, and the volumetric fluid then allowed to run in from a burette. As soon as the yellowish solution becomes reddish, it is a sign that all the chloride of sodium has been changed to silver chloride, and the formation of the red silver chromate begins. At this point the reaction is complete.

---

* See description of Ultzmann's saccharimeter, p. 301.

If to 10 c.c. of urine employed 9·6 c.c. of the volumetric solution has been added, since 1 c.c. of the same corresponds to 10 milligr. of Na Cl, 9·6 c.c. shows 96 milligr. of chloride of sodium.

If in 10 c.c. of urine 96 milligr. of Na Cl are contained, then in the twenty-four hours' amount, i. e., 1,400 c.c., we would have $10 : 96 :: 1{,}400 : x = 13{\cdot}44$ grms., of Na Cl in the amount for twenty-four hours.

Should the patient have taken an iodine or bromine preparation previous to the investigation, this will quickly pass into the urine. In order to correct the disturbance from this cause, the solution of the slag is acidified with HNO_3, and a few drops of a solution of potassium nitrite are added in order to make certain the separation of the iodine. It is then shaken up with carbon disulphide until this no longer takes up iodine (or bromine); the solution is then neutralized with sodium carbonate, evaporated, and treated as above. (Salkowski.)

Falck's method is founded upon the precipitability of sulpho-cyanates, and the property of deprivation of color which $AgNo_3$ has over the red ferric sulpho-cyanate.

X. DETERMINATION OF PHOSPHORIC ACID.

a. Reagents.

1. Sodium-acetate solution: 100 grms. of acetate of sodium are dissolved in 900 c.c. of water, and to that solution 100 c.c. of acetic acid are added.

2. Uranium nitrate solution, 1,000 c.c. of which must contain 20·3 grms. of pure uranic oxide: 1 c.c. corresponds to 5 milligr. of phosphoric acid. (Neubauer and Vogel, l. c., 199.)

3. Ferrocyanide of potassium solution.

b. Mode of Procedure.

Fifty c.c. of the urine to be investigated are poured into a beaker-glass and 5 c.c. of the sodium-acetate solution are added. This mixture is then warmed on a water-bath. When the urine is warm, the uranium solution is added drop by drop as long as a precipitate is observed. If this can not be recognized with certainty, the mixture must be stirred up, a drop brought upon a porcelain plate, and a drop of a very dilute solution of potassium ferrocyanide added. If a brownish-red color appears at the line of contact, the addition of the uranium solution must be discontinued, and the dish placed again on the water-bath until the mixture simmers. Then we try again whether the limit of the reaction has been reached; usually this is not the case, so the uranium solution is dropped in until the end of the reaction is reached. The limit of the reaction occurs when all the phosphoric acid has been precipitated by the uranium solution. After this condition is reached, the next drop of the uranium solution, finding no phosphoric acid, forms a brown precipitate with the ferrocyanide of potassium.

If we have used 13 c.c. of the uranium solution, then, since 1 c.c. of this satisfies 5 milligr. of phosphoric acid, we have the proportion, $1 : 5 :: 13 : x = 65$ milligr. The 65 milligr. are contained in 50 c.c. of urine; hence for the entire phosphoric acid in the twenty-four hours' amount we have the proportion, $50 : 65 :: 1{,}300 : x =$ 1,690 milligr., or 1.69 grm. phosphoric acid.

If we wish to determine the phosphoric acid in combination with the earths, 200 c.c. of urine are precipitated with ammonia and collected after twelve hours on a filter, and washed with ammonia water (1 part ammonia and 3 parts water). The filter is then broken at the point, and the precipitate washed down with a stream of water from a wash-bottle into a beaker-glass, and dissolved while warm with as little as possible of acetic acid. Add 5 c.c. of sodium-acetate solution, diluted to 50 c.c., and proceed as above.

Of course the difference between the total amount of phosphoric acid and the amount in combination with the alkaline earths will be the quantity combined with the alkalies (K.Na and NH_4).

XI. DETERMINATION OF SULPHURIC ACID.

One hundred c.c. of urine are heated with chloride of barium solution after acidification with HCl, and the precipitate of barium sulphate is brought upon a small filter-paper, the weight of whose ash is known, and washed until the filtrate gives no baryta reaction. Then the filter-paper and precipitate are incinerated in a platinum crucible, moistened with a few drops of sulphuric acid, and again heated to redness. After cooling under a desiccator the mass is weighed. If the weight of the crucible and the ash of the filter is subtracted from the total weight, we have the weight of the barium sulphate, from which the weight of the H_2SO_4 may be easily calculated, since in 100 weighed parts of barium sulphate are contained 34·33 parts of sulphuric acid (SO_3).

The amount of sulphuric acid may be determined volumetrically, although this method is attended with much complication and is seldom employed.

For the seldom used quantitative determination of the alkalies and alkali-earths, of indican, ammonia, biliary acids, and iodine, the works of Neubauer and Vogel, Hoppe-Seyler, etc., may be consulted.

CHAPTER VI.

KEY TO THE APPROXIMATIVE ANALYSIS OF URINE.

After the urine has been allowed to stand some hours, its physical characteristics should first be observed.

1. The twenty-four hours' amount.
2. Color and transparency.
3. Odor.
4. Reaction upon litmus.
5. Specific gravity.
6. Quantity of the sediment.

If a sediment has formed, the urine must be poured off and made use of for the several chemical tests. If the urine is quite cloudy, it should be filtered; should it not then be quite clear, it may be advantageous to warm it slightly to render it so. The sediment is set aside for analysis.

CHEMICAL INVESTIGATION.

A. Nitric Acid.

Take about 15 c.c. of clear urine in a wine-glass, and pour down the side of the glass a sub-layer of pure nitric acid (HNO_3). We find by this—

1. Albumen (p. 91);
2. Urates (p. 60);
3. Biliary coloring matters (p. 131);
4. Indican (p. 66).

If the urine contains much iodine, the zone between the fluids is colored a brilliant yellow-brown. The odor of iodine is perceived distinctly (p. 145).

If but small amounts of these matters are present, they appear only after a few minutes. It is well to set the glass aside, while proceeding with the following test.

B. Heat Test.

Fill a test-tube one third full of clear urine, and heat over a spirit lamp. If a turbidity arises, then it contains either *albumen* or the *earthy phosphates*, which are precipitated by heat. Add now one or two drops of acetic acid: the earthy phosphates will be dissolved, but the albumen remains. Add now potassium hydrate in volume equal to one half that of the urine in the tube: the albumen will go into solution, and the earthy phosphates will precipitate in small flakes. Heat the mixture again: if it becomes brown, sugar is present. If it does not become brown by boiling, set the tube aside in order to allow the phosphates to settle, that their amount and color may be noted.

The earthy phosphates of normal urine are white. If they appear colored, the urine may contain various *coloring matters;* if blood-red or dichroic, *blood-coloring matters* are present. As a confirmation of this, albumen must be present, and the crystals of hæmine should be tested for in the sediment of the urine which forms naturally, micro-chemically, or from the albumen coagulum tinged by the coloring matters, by means of the same test (p. 128). Also under the microscope we almost always find blood-corpuscles in the urine sediment.

If the earthy phosphates appear rose-red, and there is no albumen present, *plant-coloring matters* are indicated (p. 127), especially after the internal use of rhubarb and senna. As a confirmatory test we add ammonia to the raw urine: a reddish color appears, which vanishes on addition of acid.

If the earthy phosphates appear a dirty gray, usually *uroërythrine* (p. 126), the coloring matter of febrile urine is present. To confirm this there must be present a rose-red sedimentum lateritium, or, upon addition of a few drops of acetate-of-lead solution, a reddish or flesh-colored precipitate should fall.

If the earthy phosphates appear brown, usually the *biliary coloring matters* are present. If the biliary coloring matters are not decomposed, a beautiful iridescence may be obtained by Heller's test (p. 132). If no coloration occurs, and also no green color is obtained (Ultzmann's test), then decomposed biliary matters are present in the urine. By a relatively low specific gravity of the urine the H_2SO_4 test is strengthened, and a mixture of the urine with potassium hydrate (KOH) appears more darkly colored.

C. Test for the Normal Coloring Matters of the Urine.

1. Test with concentrated H_2SO_4 (p. 67, Heller's urophæine test).

2. Test for *indican* with concentrated HCl and bleaching-powder solution. (See p. 68.)

D. Test for the Normal Inorganic Salts of the Urine.

1. *For chlorides:* Take the wine-glass which has been used for the HNO_3 test A, and, if much albumen has not separated, stir up the mixture of urine and HNO_3 with a glass rod and add one or two drops of a solution of nitrate of silver ($AgNO_3$). (P. 73.)

2. *For alkaline phosphates*, with the magnesium fluid mixture (p. 80), after precipitating the earthy phosphates with KOH or NH_4OH.

3. *For sulphates*, with barium chloride (p. 82).

E. Further Tests for Abnormal Matters.

If it is necessary to test for the more obscure substances which may be present, we use the aforementioned tests for ammonium carbonate (p. 142), hydrogen sulphide (p. 143), sodium carbonate (p. 145), and for leucine and tyrosine (p. 124). When the first three bodies are present, the urine is almost always alkaline. With the latter two, biliary matters are generally present.

F. Investigation of the Sediment.

The color and consistence of the sediment should first be observed (whether crystalline, pulverulent, flocculent, etc.), and also what is its chief constituent. We may do this either chemically or better microchemically and microscopically. ("Sediment," pages 146–189.) Finally, we determine the visible organized constituents of the sediment (epithelium, cylinders, spermatozoa, etc.) by means of the microscope.

If the urine has been investigated in accordance with this scheme, it is convenient, for the beginner especially, to write in a concise form all that he has found, in order that he may draw his conclusions from a glance at the analysis.

This form may be conveniently made by simply folding a sheet of paper three times (see p. 229).

The abbreviations are as follows:

H_2SO_4 test = Sulphuric-acid test for coloring matters.
Ind = Indican.
+Ur = Urea.
—Ur = Uric acid.
Cl = Chlorides.
E. ph. = Earthy phosphates.
A. ph. = Alkali phosphates.
Sul. = Sulphates.

In order to express whether the constituents are present in normal, increased, or diminished quantity, we employ the following:

A normal amount present is denoted by n; a moderate increase by m +; a moderate decrease by m —;

a large increase by st + (strongly increased); a large decrease by st — (strongly decreased).

The results may be arranged as follows:

PHYSICAL CHARACTERISTICS.	
NORMAL SUBSTANCES.	
$H_2 SO_4$ test .	Cl . . . .
Ind " .	E. ph. . . .
+Ur	A. ph. . . .
—Ur	Sul. . . . .
ABNORMAL MATTERS IN SOLUTION.	
SEDIMENT.	
Conclusion.	

The increase and decrease is that of the percentage. Such a filled out table appears as the following example.

PHYSICAL CHARACTERISTICS.

24-hour amount = 4,000 c.c.
Pale yellow, somewhat turbid, acid.
Sp. gr. = 1·040. Slight sediment.

NORMAL MATTERS.

$H_2 SO_4$ test	st —	Cl	m —
Ind	m +	E. ph.	st —
+Ur —Ur	m —	A. ph. Sul.	st —

ABNORMAL MATTERS IN SOLUTION.

Sugar in considerable quantity.

SEDIMENT.

Consists of mucus in normal quantity.
Microscopically, isolated yeast fungi are seen.

Result = Diabetes mellitus.

With such a blank one may write in its proper division the result of each test that he has applied from A to F, the presence and amount of the substances found, and the conclusion he may have drawn. If we look at the table in the example, we conclude: 1st. From the 24-hour amount, that there exists *polyuria;* 2d. From the specific gravity, concerning the quantity of solid matters, *diabetes;* 3d. From the pale color and the lack of urates, that no febrile condition exists; 4th. Finally, from the amount of sugar present, *diabetes mellitus.*

CHAPTER VII.

GENERAL DIAGNOSIS.

At the time when the entire investigation of the urine consisted in observing the physical characteristics, and then only with preconceived notions, so that one took pains to torture the "urine signs" to conformity with a system previously constructed on a speculative basis, the investigation of the urine could afford no essential service in the diagnosis of febrile processes, and not seldom afforded a cloak to ignorance and charlatanry.

It is only since the advance of organic chemistry and the use of the microscope, and since the connection between the characteristics of the urine and the tissue metamorphosis on the one hand, and the construction of the urinary apparatus on the other, has been clearly understood, that the investigation of the urine has dared to claim for itself an important character and a scientific value. At present no one doubts that it is essentially necessary for the diagnosis of disease. Moreover, in certain cases, from the urinary analysis alone can their nature, condition, and intensity be determined. It would be a gross error to believe that from the urine all possible diseases can be diagnosed; but it would be equally unjust to attempt to exclude as useless urinary investigation.

Before we speak of the diagnosis of diseases of the urinary apparatus, we will mention what is important uroscopically with the various diseases in general. In this series we comprise those indications which are most valuable and necessary to the practicing physician.

1. Take the twenty-four hours' amount, and consider if it be normal, increased, or diminished. The normal amount is generally 1,500 c.c. If the twenty-four hours' amount is considerably increased, we have to do with *polyuria;* if it is diminished considerably, with *oliguria;* and, if there is no urine excreted, with *anuria.*

Polyuria may be either physiological or pathological. In the first case it is *urina potus* or *urina spastica;* in the latter case, on the other hand, we have either *hydruria* or *diabetes.* In order to make a differential diagnosis, we must calculate from the specific gravity the amount of solid matters excreted in twenty-four hours, by means of Trapp's or of Häser's coefficients (p. 39). If the quantity of solid matter is normal (nearly 70 grammes) or thereabout, it is a case of *urina potus;* i. e., as far as its solid constituents are concerned, a normal urine diluted with much water. If the amount of solids is diminished, we have a *hydruria* to treat, which may occur with several cachexies. If, on the contrary, the solids are considerably increased, we have a *diabetes.* If with the diabetes a large amount of sugar is present, we have a *diabetes mellitus.* If, on the contrary, no sugar is present, we have a *diabetes insipidus* (by an increase of the nitrogenous materials, an *azoturia*).

Oliguria is easy to diagnose, and occurs chiefly with febrile processes. The urine is generally dark-colored and strongly concentrated. In the latter stages of kidney diseases, after the appearance of uræmia, the amount constantly decreases. A slight oliguria may occur temporarily after a loss of water, as by profuse sweating or diarrhœa.

Anuria with an unobstructed urethra occurs only in severe kidney affections, in connection with uræmia. Besides, this occurs with stricture, stone, and new growths, as so-called retention of the urine.

If the amount of urine has been satisfactorily investigated, we observe:

2. Whether or no the specimen is a febrile urine. We may also often determine whether the febrile process is acute or chronic, since the acute inflammatory processes are usually accompanied by important febrile indications.

Febrile urine has generally a dark reddish-yellow color, is concentrated, and its volume likewise diminished. If, as is seldom the case, the amount of urine is not diminished, but on the contrary is increased, the coloring matters are likewise increased. We regularly find in fever urine a distinct layer of urates by the HNO_3 test (A).

If an acute exudation process is present at the same time, the urine is concentrated, acid, and contains many urates, which come down upon cooling, colored by a red coloring matter (uroërythrine) as a rose- or tile-red sedimentum lateritium. At the same time the excretion of the urea, sulphates, and alkali phosphates is increased, while the chlorides are diminished. With an increase of the disease the chlorides may steadily diminish, until they finally disappear at the climax.

In the stage of resorption the concentration of the urine gradually disappears, the reaction becomes gradually neutral or alkaline (from carbonate of ammonia), the chlorides are again present in normal amount, and in the sediment are found urates (as urate of ammonium) and earthy phosphates. Simultaneously the urine may be normal in volume or somewhat increased, while during the exudation process it was diminished.

Although in most cases it is not very difficult to diagnose from the urine an acute inflammation or a so-called status febrilis, we are not able to make (excepting the diseases of the urinary apparatus) a differential diagnosis between the various forms of febrile affections. Even in the kidney diseases one may be so far deceived that, being misled by the uroscopic indications, he may mistake an accompanying affection for the principal disease. For example, the urine of scarlatina is analyzed, and one finds a febrile state in connection with a desquamative or parenchymatous nephritis. From the uroscopical indications we diagnose acute nephritis, although scarlatina and not nephritis is the predominant disease. The former could not be diagnosed from the urine.

Notwithstanding that the differential diagnosis of febrile affections is not possible, the analysis of the urine should not be omitted, since from it we may often determine an advance or improvement in the condition, and often detect further complications. For example, the reappearance of the chlorides is regarded as a favorable sign, while the appearance of albumen is an unfavorable symptom.

Among the acute febrile processes there are a few to be mentioned which lend characteristic peculiarities to the urine, and which are of essential importance to the physician to confirm his diagnosis.

With *icterus* we constantly find biliary matters in the urine.

With *icterus levis*, an icterus of a lighter grade, simply a febrile state is discovered (i. e., much urates in an acid, dark, concentrated urine), and a rich mass of biliary coloring matters, the chlorides at times appearing in less quantity. With *icterus gravis*—in which the principal cause is not simply a resorption of the biliary constituents, from a catarrhal affection of the ductus choledochus and cysticus, but much more a parenchymatous affection of the liver itself, often also a quick breaking down of the liver cells—besides a large quantity of the urates and biliary coloring matters, we find also albumen, and at the same time small amounts of the biliary acids. The chlorides are entirely wanting.

With *acute liver atrophy* we usually find a urine rich in biliary coloring matter, of low specific gravity and acid reaction. The urea is greatly diminished, and in its place we find leucine and tyrosine (the latter also as a sediment). The chlorides have entirely disappeared. Moreover, urates and albumen, the latter in great amount, are present. Biliary acids can be proved in such urine. In the sediment is found a great amount of epithelial casts and fibrinous cylinders, besides kidney epithelium and isolated blood-corpuscles.

With *acute lung diseases* we find a larger amount of urates corresponding to the insufficiency of respiration.

With *heart diseases*, or irregularities of the circulation, we find a stasis in the venous system and resulting albuminuria (renal stasis); just as there occurs with many acute febrile diseases, and especially exanthemata, a kidney affection as a complication.

With *peritonitis* we find usually a large amount of indican. (Senator.)

The urine of *meningitis* is generally very strongly concentrated, corresponding to the slowness of the pulse. Since the differential diagnosis between meningitis and typhus is very difficult, and clinically often impossible, various indications may be gathered from the urine. Unfortunately, they are not to be entirely depended upon. The urine of meningitis should show a high specific gravity and a weakly acid reaction, and should contain some albumen and much urates. Besides the increase of the specific gravity, another characteristic should be that, by boiling the native urine, the earthy phosphates should separate (Heller's bone earths). The chlorides are not strongly diminished. In typhus, on the contrary, the specific gravity is not so high, and the urine is acid and should contain no so-called bone earths.

The chlorides should almost always be greatly diminished. Urates are present, and albumen may be found in larger amount. At the same time in typhus urine a large amount of carbonate of ammonium should be proved, the urine at the same time possessing a distinctly acid reaction.

With *meningitis spinalis* one should find besides these constituents much indican. The specific gravity of this urine, in contradistinction to that of *meningitis cerebralis*, should be lower.

With *acute articular rheumatism* we observe, besides a high specific gravity, an acid reaction, increased urea and urates, and a characteristic strong increase of earthy phosphates. The sediment should contain beautiful rose-red urates and oxalate of calcium, colored by uroërythrine. If pericarditis exists also, the chlorides and earthy phosphates diminish rapidly, but the uroërythrine appears still more beautiful.

If the urine is not colored dark reddish-yellow, and urates are not present in large amount, we may determine that no febrile process accompanies the disease. Among the feverless and consequently for the most part chronic affections, several possess certain characteristic peculiarities in the urine, which for completeness we mention.

Chlorosis furnishes a very pale and light urine, corresponding to the lessened tissue-metamorphosis in the organism. With *hysteria* a similar urine appears, but with an increase at times in mass, and a larger amount of indican (*urina spastica*). The urine of *hydruria* and *diabetes* is also pale. How these two may be distinguished from one another has been already explained. With *diabetes mellitus* the specific gravity is higher in spite of the increased amount. An increase of indican is observed by the reaction, and in the later stages of this disease much albumen appears. The remaining normal constituents are diminished in percentage, but the absolute amount (with the exception of uric acid) is increased. In saccharine urine very many and beautiful yeast plants are found in the sediment, as well as networks of penicillium.

With *chronic diseases of the spinal cord* often occurs a pale and light urine, which besides much indican and bone earths contains a very small quantity of sugar (?). In the sediment Heller claims to have often observed sarcinæ.

With *rachitis*, and especially with *osteomalacia*, the earthy phosphates are strongly increased, so that they form a copious sediment.

With *diseases of the bone*, especially if a great part of the skeleton is involved, we find an increase of carbonate as well as oxalate of lime in the sediment, together with the so-called bone earths, partly in solution and partly in the sediment.

With *chronic articular rheumatism* is found a strongly acid, concentrated urine, which contains a sediment rich in urates and calcium oxalate. A great increase of earthy phosphates is characteristic.

In *gout* we find a similar urine, except that the uric acid is excreted in less amount, and is therefore retained in the organism. At times a beautifully crystallized sediment of free uric acid is found.

In *intermittent fever*, in the cold stage, the excretion of urine is increased, and it is light and clear, while in the hot stage it is dark and saturated.

In *chronic liver affections*, in spite of the fact that no fever exists, we find a dark, acid, concentrated urine. Undecomposed biliary coloring matters are seldom present; the normal coloring matters are strongly increased (decided $H_2 SO_4$, and indican reaction); and generally uroërythrine is also present. This increase of the coloring matters of the urine is accounted for by an increased exchange and excretion of biliary coloring matters. The earthy phosphates are usually diminished. In the sediment we find frequently urates colored rose-red by uroërythrine, and many times a small amount of calcium oxalate.

In *chronic skin diseases*, especially in those affections which destroy in part the function of perspiration, we find regularly a kidney disease as a complication; i. e., pemphigus, etc.

With *scurvy* and *purpura hæmorrhagica* we frequently find hæmorrhage from the kidneys; as also in *melanæmia*, with which we usually have parenchymatous kidney affections.

With *leucæmia* the urine is rich in uric acid, and often also hippuric and lactic acids occur.

CHAPTER VIII.

DIAGNOSIS OF THE DISEASES OF THE URINARY APPARATUS.

If urine which contains neither pus nor blood, nor has been accidentally mixed with albuminous fluids, shows the albumen reaction, this condition is called *true albuminuria;* and disease of the kidney itself is indicated. If, on the contrary, albumen is present only as blood or pus, the condition is called *false albuminuria,* and is usually a symptom of an affection of the kidney-pelvis, ureters, or bladder. *Mixed albuminuria* is when there is more albumen in the urine than can be accounted for by the presence of blood and pus.

Whether, in addition to the amount contained in blood and pus, albumen in other forms is present in the urine, can only be accurately determined by one very familiar with the albumen reaction, and sometimes even he will find it quite difficult. The best way of learning to distinguish false from mixed albuminuria is to add to normal urine the so-called healthy pus of a suppurating wound, and, after allowing the sediment to form, apply the test for albumen.

MICROSCOPICAL AND CHEMICAL AIDS FOR DIAGNOSIS OF THE DIFFERENT FORMS OF ALBUMINURIA.

A. True Albuminuria.

1. *Hyperæmia of the Kidney.*

From the active congestion caused by unusual imbibition, no albumen is found in the urine. The daily amount of urine is increased, its color becomes pale yellow or may be clear as water, the specific gravity is very low, and the normal solid constituents are usually excreted in greater quantity.

Albumen in small quantity is present in urine when for a considerable time the kidneys have been obliged to perform their function excessively, as for example in diabetes mellitus or insipidus. It also appears in small quantity (one tenth per cent., and generally even less) from hyperæmia of the kidney, caused by various irritating substances which are excreted by the same; for instance, after the long-continued internal use of balsam copaivæ, turpentine, cubebs, corrosive sublimate, and other acrid or astringent remedies.

A change in the chemical constitution of the urine should also be mentioned as a cause of irritation; that is, hyperæmia of the kidney. It is well known that a concentrated, strongly acid urine may give rise to manifold disorders of this organ, and may sometimes even cause a slight albuminuria, which is, however, generally transitory.

Partly from chemical and partly from mechanical irritation, as by oxaluria and excessive amount of uric acid in the urine, especially if this fluid has a strongly acid reaction and the uric-acid crystals are pointed or jagged, a mild albuminuria may be produced. This can however be easily cured, if one pays attention to the character of the urine, and induces the patient to drink a great amount of water; for by this means the solids of the urine, especially the alkali-salts, are excreted in greater quantity, which, besides neutralizing the acidity of the urine, are excellent solvents of the uric and oxalic-acid crystals.

The crystals of uric acid, in addition to their irritative action, not infrequently become kernels for the formation of renal calculi.

Further, a slight temporary albuminuria is observed after convulsions, epileptic and intermittent fever paroxysms, and various other forms of vascular contraction. It also frequently occurs in conjunction with acute fevers (Bartels' febrile albuminuria), especially with acute exanthemata, and finally sometimes with inflammatory affections of the skin, as anthrax, furunculosis, erysipelas, burns, etc. Often by hyperæmia of the kidney, if the primary disease advances, a parenchymatous inflammation is introduced.

From passive hyperæmia of the kidney, a result of general venous sluggishness, the albuminuria increases or diminishes in proportion to the more or less complete venous stasis.

Often a retardation of the renal circulation results from feebleness of the heart's action. If, however, in such cases the normal blood-pressure is restored by proper medicines, the albuminuria usually disappears. The renal circulation is also impaired by chronic pulmonary diseases, especially emphysema, and by all tumors and exudations which retard the general current of the venous blood; as, for example, large pleuritic effusions, ascites, ovarian cysts, and advanced pregnancy. Puerperal eclampsia is not alone accompanied by a transitory renal venous stasis (Rosenstein), but very frequently also by parenchymatous nephritis (Bartels).

As a consequence of marasmus and with various cachexies, a hyperæmic condition of the kidney is observed.

The characteristics of simple *hyperæmia of the kidney* are that the specific gravity of the urine is generally though not always high, the amount is diminished, or else normal in quantity, and the reaction is acid. Albumen appears in small quantity (one tenth per cent. or even less). In the sediment either no organized elements are found, or at most single blood-corpuscles and epithelial cells from the straight tubules; hyaline casts are scarcely ever seen.

In *febrile albuminuria*, in addition to this, the quantity of the urates is increased, while that of the chlorides is greatly diminished.

In *stasis of the renal circulation* proper, the twenty-four hours' amount of the urine is always diminished, the specific gravity is high, the color dark, and the reaction acid. This urine contains a large amount of urates, which frequently render it turbid, and settle down as a copious sediment. About one fifth per cent. or more of albumen is present. In the sediment are usually found hyaline casts and single cells of kidney epithelium.

This renal stasis is distinguished from parenchymatous nephritis by the absence of cellular forms (blood- and lymph-corpuscles, granular epithelium from the kidney) and of granular casts in the sediment of the urine.

The urine accompanying renal stasis is distinguished from that of chronic interstitial nephritis (cirrhosis of the kidney), and that of the "waxy" kidney, by its dark color, its high specific gravity, its small amount during the twenty-four hours, and the abundance of its urates.

2. *Parenchymatous Nephritis.*

Two forms of parenchymatous nephritis are accepted—acute and chronic. The acute form usually occurs as a sequence of other acute diseases, and is seldom primary; while the chronic, the so-called second stage of Bright's disease, is generally primary, and seldom follows the acute form.

a. Acute Parenchymatous Nephritis.

Of acute parenchymatous nephritis two forms are to be recognized. One is a slight affection, the so-called catarrh of the urinary tubules, or desquamative nephritis; the other a more severe form, the acute parenchymatous nephritis proper (diffuse or croupous), the so-called acute Bright's disease.

Acute parenchymatous nephritis in most cases allows a favorable prognosis. Only in those cases where there is a complete suppression of the urinary secretion (anuria) is there usually a fatal termination. Desquamative nephritis always runs a favorable course.

a. *Catarrh of the urinary tubules, or desquamative nephritis.*—This form preferably affects the straight tubules. It lasts from eight to fourteen days, but often a still shorter time. Fever is not an essential characteristic. Those affected complain of stiffness in their joints, pain in the region of the sacrum, and general lassitude. They frequently walk about during the whole course of the disease. Œdema seldom occurs.

The urine shows the following characteristics:

The twenty-four hours' amount is either normal or slightly diminished; the same is true of its specific gravity. The color is wine-yellow, seldom a dirty yellow; the reaction is acid. The fluid is always rendered turbid by the presence of cellular bodies, and sometimes deposits a thick sediment.

The normal constituents are excreted in normal proportion.

Of abnormal substances, albumen is found in moderate quantity, one tenth to one fifth per cent., and sometimes traces of blood-coloring matter.

The sediment consists chiefly of an increased amount of mucous secretion. Microscopically are seen numerous epithelial cells from the straight tubules, which are sometimes colored brown by the coloring matter of the blood. They are frequently connected together in the form of hollow cylinders, being known as epithelial casts; or the epithelial cells may form the covering of a hyaline cylinder (both together forming the epithelial cylinders). (Pl. VII., A., 5.) In addition are found isolated hyaline cylinders, red blood-corpuscles, and a somewhat larger number of lymph-corpuscles.

Inflammation of the straight tubules also results from the introduction of instruments after catheterization of a sensitive bladder, dilatation of strictures, introduction of the lithotrite, etc. It also accompanies acute inflammatory processes, especially the exanthemata.

Ex contiguo, desquamative nephritis arises from inflammation of the bladder caused by the retention of urine after gonorrhœa.

The higher degree of this affection is—

β. Acute parenchymatous nephritis proper.—This disease may occur with very severe disturbances, and also without noteworthy subjective symptoms. The latter condition is observed in reduced cachectic individuals.

The important symptom, which first causes the patient as well as the physician alarm, is dropsy. This appears especially characteristic as œdema of the face, which produces a bloated appearance. Severe cases are accompanied by anuria and convulsions. The less the twenty-four hours' amount of urine, so much the more severe generally becomes the disease; so that with an anuria of long duration the disease usually proves fatal.

The urine shows the following changes:

The twenty-four hours' amount is greatly diminished, often to 250 c.c. The specific gravity is usually increased; the reaction is acid, and the urine has a brown-yellow, dirty color, being quite turbid from the presence of many cell elements. The latter after long standing settle as a considerable sediment.

The normal constituents are excreted in diminished amount.

Of the abnormal matters, we find serum-albumen in great amount, and at times blood-coloring matters also in considerable quantity. Albumen comes in from 1 to 5 or 6 per cent., so that the urine is transformed by boiling to a thick jelly.

The sediment is generally colored brownish, and consists principally of a thick mass, often colored brown by blood-coloring matters, at times of long corkscrew-twisted fibrine-cylinders, containing often a great amount of lymph- or red blood-corpuscles (blood-cylinders) or adhering brown-colored (hæmorrhagic) epithelium of the urinary canals. In other cases we find only cell remnants surrounding distinctly visible nuclei, which are in part contained within and in part on the surface of the cylinder. Besides, many isolated epithelial cells from the tubules are found, together with many blood- and lymph-corpuscles, and a mass of molecular detritus, richly colored brown from the blood-coloring matters.

Acute parenchymatous nephritis either develops itself primarily, or it occurs as a consequence of another acute disease. It appears especially frequent after acute exanthematous affections, namely, after scarlatina, and as a consequence of diphtheritis, febris recurrens, phlegmon, erysipelas and carbuncle, after employment of preparations of which cantharides may be taken as the type, and also after the internal exhibition of violent and caustically acting medicaments, as corrosive sublimate.

It is frequently observed after taking cold, and after burns of wide extent on the skin. After articular rheumatism, in cholera, and in pregnancy it appears frequently as a complication.

Finally, acute nephritis occurs frequently in the course of chronic parenchymatous nephritis.

Although the prognosis in most cases of this disease, even if it has lasted several weeks or months, is favorable, yet in single severe cases, with the appearance of acute uræmia, the fatal end may come in a few days. On the other hand, the acute form may pass over to the chronic.

b. Chronic Parenchymatous Nephritis.

The first symptom of this disease is also dropsy. Fever is not present.

The urine shows the following changes:

As long as chronic nephritis advances, or while the disease remains at its height, the twenty-four hours' amount is diminished; but as soon as the chronic nephritis retrogrades, the amount of urine increases, and in the stage of the so-called kidney atrophy it may pass beyond the normal amount.

The color of the urine is dirty yellow, often brown-yellow. It is turbid from numerous cell forms, which after settling show a macroscopically visible sediment. The reaction is acid, and the specific gravity is usually lowered.

The normal constituents (especially urea) are excreted in diminished quantity.

Of the abnormal substances, albumen is found from one half to one or two per cent. Blood-coloring matters are present; at least, traces are provable.

In the sediment we find at times in large amount, but usually isolated, dark nucleated granular cylinders, or half granulated, made up of a hyaline ground-substance with insulated granular masses sparingly distributed over its surface. (Pl. VII., A, 2.) There are also found nucleated granular kidney epithelium and single blood- and lymph-corpuscles, with molecular detritus.

In the condition of secondary atrophy the twenty-four hours' amount is considerably increased. The specific gravity is much lowered. The color is pale yellow. The urine is also turbid, and shows a macroscopically visible sediment.

The excretion of the normal constituents, especially the urea, when the atrophy affects both kidneys, is greatly diminished.

Albumen is present in only small amount (one tenth to one fifth per cent.).

In the sediment we find granular masses consisting of detritus, granular kidney epithelium, and isolated fragments of granular cylinders.

This disease occurs in a minority of cases as a sequence of the acute nephritis, but generally it has other modes of origin.

Chronic parenchymatous nephritis arises from the acute parenchymatous nephritis, though most frequently after scarlatina, after severe rheumatic processes, after profuse bone suppuration, and also from the nephritis of pregnancy.

Parenchymatous nephritis originates in the chronic form after purulent osseous and articular inflammations in consequence of intractable syphilis, pulmonary phthisis, malaria, scrophulosis, and other cachexies; also from the immoderate use of spirituous liquors, which is of especial importance.

The prognosis is not very favorable. There are indeed cases in which, after years of a dropsical and albuminurious condition, recovery has taken place, though this termination is not the usual one. After syphilis and malaria we may by energetic treatment secure healing, and also after a profuse osseous suppuration, when the contained pus has been gotten rid of surgically.

3. *Interstitial Nephritis.*

The interstitial connective tissue of the kidney may be altered either by hyperplastic growth or by destructive suppuration. Accordingly we distinguish two forms of this disease, the hyperplastic interstitial nephritis and the suppurative interstitial nephritis.

a. Hyperplastic Interstitial Nephritis—Cirrhosis of the Kidney—Genuine Kidney Atrophy.

This affection occurs most frequently in advanced life, very seldom in youth.

Cirrhosis may have existed for a long time, and may have attained a high grade, without the patient having by any symptom whatever suspected any disease of the kidney. Dropsy occurs not at all, or only in the last stages.

A tense and quick pulse and a hypertrophy of the left ventricle are the usual symptoms of this form of disease of the kidneys.

Disturbances of vision complicate especially this form of the kidney diseases, and are not seldom the first symptom for which the physician is summoned.

The urine shows the following conditions:

The external appearance after excretion is similar to that of normal urine. It is bright and clear, and shows sometimes a darker, sometimes a lighter color, corresponding to its concentration. The twenty-four hours' amount is generally increased, though polyuria is not always the rule. The specific gravity is either normal or more frequently lowered. The reaction is acid.

The normal constituents are usually excreted in normal mass.

Of the abnormal constituents, albumen is found in moderate amount (0·1, 0·2, 0·5 per cent.). It may also entirely disappear from the urine. This happens especially in a condition of perfect rest; hence more is found in the day than in the night urine.

Macroscopically we do not observe a sediment after long standing. Usually we find nothing abnormal by our microscopic investigation. Only at times, when after long standing we pour off all but the last drop of the urine, and then examine this thoroughly by the microscope, we find a hyaline cylinder, a blood-corpuscle, or a little changed kidney epithelium.

The prognosis of this disease, if the diagnosis is correct, is an unfavorable one, though the course of the disease may be long.

The ætiology is obscure.

b. Suppurative Interstitial Nephritis.

This may be of traumatic, idiopathic, pyæmic, or metastatic origin. It often proceeds from chronic pyelitis, when the disease of the pelvis extends to the connective tissue of the kidney and sets up suppuration. It is this usually which, after surgical interference with the urinary organs, closes the scene. Suppurative nephritis occurs in this way, after catheterization of a paralyzed bladder, after forcible dilatation of strictures, and after lithotrity. It was on this account that this disease was formerly known as surgical kidney.

Kidney calculi predispose especially to suppurative nephritis, and that complicated with great kidney abscesses and pyonephrosis.

The urine shows the following conditions:

It has a dirty yellow color, is cloudy, and is passed in small quantity. The odor is putrid. The specific gravity is diminished, the reaction being usually neutral or alkaline.

The normal constituents, especially urea, are excreted in diminished quantity.

Of the abnormal constituents, albumen is present in greater mass ($\frac{1}{2}$ to 1 per cent.). Blood-coloring matters are usually present. Not seldom carbonate of ammonium and ammonium-sulphide are present in greater quantity.

The sediment is considerable, and consists chiefly of flocculent pus mixed with blood in greater or smaller amount. Microscopically are found, besides numerous bacteria, molecular detritus and kidney epithelium, and not seldom beautifully formed, thick, often-branched cylinders, which are formed of bacteria (pyelo-nephritis parasitica, Klebs). If it is complicated with parenchymatous nephritis, we find also dark, granulated, mostly thick cylinders from the straight tubules.

The course is usually acute, and the process generally ends fatally. In chronic cases the large abscesses discharge into the pelvis of the kidney.

We can only diagnose kidney abscesses by estimating the amount of pus excreted per diem, which we can easily do with graduated cylinders. A suddenly appearing and then disappearing amount of pus in the urine, together with microscopical evidences of broken-down kidney-tissue (glomeruli, tubules, etc.), furnish the best points for the diagnosis.

4. *Amyloid Kidney.*

Amyloid degeneration of the kidney is generally a local manifestation of a constitutional disease. It occurs therefore frequently in connection with extended osseous suppuration, as well also as with other long continuing and profuse suppurations. With pyonephrosis on one side, not seldom the other kidney becomes amyloid. Scrophulosis, chronic tuberculosis, and obstinate syphilis, and at times also malarial cachexy, favor especially amyloid degeneration of the kidney. In rare cases this affection is due simply to disturbance of nutrition. Frequently it is complicated with parenchymatous nephritis.

The amyloid disease of the kidney is developed quite insidiously and without marked symptoms, though as a rule the amyloid kidney excretes a larger amount of urine in twenty-four hours than the healthy kidney in the same space of time. This excess is never so great, however, as is usually found in general atrophy of the kidney.

The urine shows the following conditions:

It is pale yellow, clear, and has a low specific gravity and acid reaction, and deposits no visible macroscopic sediment.

The normal constituents are generally excreted in diminished amount.

Of the abnormal matters, serum-albumen is present in moderate quantity (from 0·1 to 1–2 per cent.). Besides serum-albumen, we often find globuline in relatively considerable mass (Senator, Edlefsen), which may be regarded in such cases as characteristic of this disease.

In the sediment, seldom visible macroscopically, are found generally no cell-elements, but sometimes narrow hyaline, or also broader waxy, glistening, fragile, yellow-colored cylinders. (Pl. VII., A, 4.) Occasionally we observe brightly glistening, amyloid, degenerated kidney epithelium, which, in the same manner as the waxy cylinder, is colored reddish brown by a watery solution of iodine, and further upon addition of sulphuric acid a dirty violet color. Blood does not appear in the sediment with pure amyloid kidney.

The prognosis depends upon the constitutional disease. If one has to do with syphilis and malaria, favorable response to treatment may be expected.

In the *differential diagnosis of the various forms of albuminuria*, the following points are to be observed:

1. If already in the urine a macroscopically visible sediment is present, consisting of a great mass of cell-elements (blood-corpuscles, pus-corpuscles, cylinders, etc.), we have to do either with parenchymatous or suppurative insterstitial nephritis.

a. In parenchymatous nephritis we find in the sediment epithelial, fibrinous, and granular cylinders, kidney epithelium, and blood- and lymph-corpuscles.

b. In suppurative interstitial nephritis we find in the sediment blood- and pus-corpuscles, much bacteria, and sometimes also bacterian cylinders, or short and thick darkly nucleated granular cylinders.

2. If the urine is clear or only clouded by urates, and no sediment is discovered which consists of a considerable mass of cell-elements, then we have to do with renal stasis, or with a hyperplastic interstitial nephritis, or with an amyloid kidney.

a. Renal stasis is distinguished from both the other diseases of the kidney by a decrease in the twenty-four hours' amount of urine, by its dark color and high specific gravity, and often by the abundance of urates. The amyloid kidney and the hyperplastic interstitial nephritis are characterized by an increase of the amount of urine; also in both diseases the urine is bright and clear, of pale yellow color and low specific gravity.

b. Amyloid kidney differs from interstitial nephritis in that the urine contains globuline, and by the presence of waxy cylinders and amyloid degenerated kidney epithelium.

Clinically we very constantly find with amyloid kidney (as with parenchymatous nephritis) dropsy, while with genuine atrophy this occurs seldom, and if at all in the latter stages.

In genuine kidney atrophy is found constantly hypertrophy of the heart and a quickened pulse, while these do not occur in parenchymatous nephritis and with amyloid kidney.

Finally, with amyloid kidney usually there is an enlargement (amyloid degeneration) of the liver and the spleen.

B. Forms of Mixed Albuminuria.

Mixed albuminuria is recognized from the fact that there is more albumen present than corresponds to the amount of pus in the sediment. It includes those diseases of the kidney-pelvis which in advanced stages involve the kidney-structure, and thereby complicate the pyorrhœa with true albuminuria.

The kidney-pelvis is limited toward the kidney by the calices and the papillæ renales. It is therefore easy to understand how with extended inflammation of the kidney-pelvis the neighboring papillary part may become involved. A proof that the papillary part of the kidney has become involved by the pyelitic process, is the presence of kidney-epithelium in the sediment. One also finds in long-continued suppurative processes in the pelvis of the kidney, that the same is enlarged at the expense of the papillary part, the latter being more or less consumed.

1. *Pyelitis.*

Pyelitis is often a local manifestation of an acute febrile process; it not infrequently accompanies parenchymatous nephritis and (in advanced stages) diabetes mellitus. The use of copaiva balsam, cubebs, and similar powerful medicaments, sometimes has this disease as a consequence. Kidney-stones, parasites, new growths, and tuberculosis of the kidney-pelvis are almost always accompanied by suppurative pyelitis. From contiguity, either this or pyelo-nephritis is developed by the damming back of the urine in prostatic hypertrophy, paralysis of the bladder, stricture of the urethra, etc., provided at the same time a purulent bladder-catarrh is present. Pyelitis also frequently arises from compression of the ureters by tumors, large exudations, or a retroflected or pregnant uterus. Finally, it may occur also after maltreatment of gonorrhœa, or mechanical injuries to the neck of the bladder and the bladder proper with surgical instruments, etc.

We may distinguish an acute and a chronic pyelitis. Not infrequently the sediment of the urine furnishes means for the diagnosis of pyelitis calculosa and tuberculosa.

The constitutional diseases which bring about pyelitis crouposa and diphtheritica are so severe in themselves that they obscure the symptoms of the pyelitis.

a. Acute pyelitis.

The clearest form of acute pyelitis occurs after surgical interference with the urinary organs, in the course of acute inflammatory processes, and after improper treatment of gonorrhœa.

The twenty-four hours' amount is diminished; the urine is dark-colored and turbid, and has a high specific gravity and an acid reaction. After standing, a distinctly visible precipitate appears.

The excretion of normal matters is not essentially changed; it shows in a high degree the peculiar characteristics of a febrile process (the urates considerable, the chlorides diminished).

Of the abnormal constituents, albumen occurs always in far greater amount than corresponds to the slight pus sediment. The percentage of the albumen varies from 0·1 to 0·5 and thereabouts. Blood-coloring matters are in small amount, and not constantly present.

The sediment consists chiefly of an increased (cloudy) mucous secretion, mixed with pus in less or greater amount. Microscopically, we find pus-corpuscles of round, spherical form, and often many adhere together, forming a cylindrical plug. These cylindrical plugs arise from the papillæ renales, and contain not seldom beautiful kidney-epithelium. We always find blood-corpuscles, but at times only singly. The epithelium of the papillary part of the kidney appears in great amount in oval or pear-shaped forms. Often two or three epithelial cells hang together. We also find at times, though seldom, these epithelial cells colored reddish brown by the blood-coloring matters, which with the colorless pus-cells and the yellow blood-corpuscles make up a beautiful picture under the microscope.

The so-called single and double caudate epithelium, with tile-form arrangement, which is generally designated as pelvis-epithelium, is not a characteristic of pyelitis. The epithelium of the kidney-pelvis does not differ essentially from the epithelium of the bladder, which appears also in the urinary sediment of pyelitis; and on this account only the epithelium of the papillary part is a characteristic for the diagnosis of pyelitis.

With acute pyelitis kidney-epithelium occurs in greater amount, often ten pieces in the field, while with chronic pyelitis it appears very sparingly.

Acute pyelitis, if it occurs in consequence of surgical interference in the bladder, or following acute inflammatory processes, or with gonorrhœa, allows of a favorable prognosis, since in the course of a few weeks healing is apt to occur. Sometimes, however, there arises from the acute form—

b. Chronic Pyelitis.

In chronic pyelitis the twenty-four hours' amount of urine is increased. For this reason polyuria may be regarded as a characteristic symptom. In severe cases, not infrequently 5 to 6 litres are evacuated in the twenty-four hours. The color of the whey-turbid urine is pale straw-yellow, and has at times a peculiar tendency toward greenish-yellow. The specific gravity is always low and the reaction acid. The sediment is more or less copious, corresponding to the amount of pus.

The absolute amount of normal constituents is not essentially changed, but their percentage appears to be diminished on account of the polyuria.

Of the abnormal constituents, albumen appears constantly in greater amount than corresponds to the contained purulent sediment. The mass of albumen is generally 0·1 to 0·5 per cent. Blood-coloring matters are usually not present.

The sediment has a greenish-yellow color, is flocculent, consists chiefly of pus, and does not stick to the glass. The pus-corpuscles with long-continued pyelitis are often branched or have tooth-like projections, unlike the pus-corpuscles of other acute purulent catarrhs of the urinary passages. They also form, since they are pressed together in greater mass, roundish, oval, or even long plugs (purulent plugs of the ductus papillares), which are characteristic of chronic pyelitis. (Pl. VII., B, 2 and 4.)

Epithelial cells are very sparingly present in chronic pyelitis; and if the suppuration is very severe, they may be entirely wanting, since they apparently by endogenous cell-formation break up into pus-corpuscles.

Blood-corpuscles do not occur with the common chronic pyelitis. With pyelitis in consequence of renal calculi, tuberculosis, new growths, and entozoa in the kidney, they are, however, of constant occurrence.

Chronic pyelitis only seldom admits of a favorable prognosis. In our latitudes it is usually complicated with primary or even (in consequence of suppuration) secondary stone-formation. Not infrequently it passes over into pyonephrosis, later perinephritis, with final discharge of the purulent contents toward the outer surface of the body, less often into the bladder or intestines. This happens usually in young or strong individuals. In weak or old patients chronic pyelitis passes over into interstitial suppurative nephritis, and chronic uræmia closes the scene.

c. *Pyelitis Calculosa.*

Calculosis renalis is chiefly introduced by a deposit of uric acid within the kidney or the kidney-pelvis. Therefore the spontaneously arising kidney concretions, for the most part, are composed of uric acid or its salts, and have a yellowish-brown color. In addition, renal calculi may be introduced by excretion of cystine (most infrequent), and by excretion of earthy phosphates, as the so-called secondary stone-formation in the kidney-pelvis, in consequence of hæmorrhage and long-continued suppuration. Oxalate of calcium only very rarely is the primary cause of stone-building; it plays its part later in the layer formation.

The most frequent cause of the formation of kidney-stone, as we have before mentioned, is the excretion of crystalline uric acid within the kidney, in consequence of its absolute or relative (through concentration of the urine) excess. Naturally the concentration and the increased acidity thereby produced furnish favorable conditions for the formation of the characteristic rough or pointed crystals of uric acid, which are almost constantly the foundation of kidney-stones (Ultzmann, "Ueber Harnsteinbildung," in "Wiener Klinik," 1875, No. 5). Therefore the indications of kidney-stone must be looked for in a concentrated, acid urine, rich in uric acid, especially if the same is excreted in jagged or pointed forms.

The beginning of kidney-calculi can be diagnosed if, in connection with the above-mentioned conditions of the urine, a light albuminuria (hyperæmic condition of the kidney) is observed, and a few blood-corpuscles appear in the sediment.

The accompanying albuminuria is only temporary, and appears, usually, only with a considerable concentration of the urine or with a great excess of uric acid.

The presence of large concretions in the kidney may be diagnosed from the occurrence of a parenchymatous hæmorrhage. The urine from the before described chemical constitution shows, especially after violent bodily exercise, a red-brown or coffee-colored tinge.

If the concretions do not disappear after such a strong kidney-hæmorrhage, there arises gradually a pyelitis—the *pyelitis calculosa.* This may occur in two forms, a light and a severe.

The light form occurs generally with kidney-concretions of small size, and characteristic indications are often offered by the sediment; while the more severe purulent form differs from the ordinary pyelitis chronica, in that we constantly find blood-corpuscles in the sediment. The latter form of pyelitis calculosa occurs generally with greater concretions, and affords later a termination for pyonephrosis and paranephritis with discharge of purulent matter.

The lighter form of pyelitis calculosa shows the following characteristics of the urine:

The twenty-four hours' amount is not increased, but rather diminished, or more commonly normal. The urine is dark-colored and turbid; its specific gravity normal or raised; the reaction acid; and often there is considerable sediment.

Of the normal constituents, uric acid is in excess (presence of crystalline uric acid in the sediment and proof of a layer of urates by the HNO_3 test).

Of the abnormal constituents, we find albumen in from 0·1 to 0·5 per cent., always more than corresponds to the pus and blood in the urine. Also blood-coloring matters are constant, though they may be present in very small amount.

The sediment consists chiefly of pointed uric-acid crystals, cystine and calcium oxalate, mixed with flocculent pus in greater or less quantity. (Pl. II., B.) Besides these, numerous blood-corpuscles (microcytes) and kidney-epithelium cells are visible.

The symptoms enumerated and the negative results from sounding the bladder confirm the diagnosis.

Pyelitis calculosa admits of a favorable prognosis only with concretions of small size, i.e., such as may pass through the ureters. With large and branching concretions, the prognosis is always unfavorable, or at least very dubious. The more severe the suppuration and the longer its duration, the more unfavorable the prognosis.

The disease affects usually only one kidney.

d. Pyelitis Tuberculosa.

Pyelitis tuberculosa is usually a local expression of a general tuberculosis, or a tuberculosis of the genito-urinary apparatus. It is on this account not seldom complicated with the appearance of a chronic parenchymatous disease of the kidney (nephrophthisis, nephritis ulcerativa). In those cases where tuberculosis of the kidney-pelvis is complicated with tuberculosis of the kidney, we find in the sediment large, waxy, shining cylinders, much molecular detritus, blood- and pus-corpuscles, and kidney-epithelium. The urine contains a large amount of albumen.

Simple pyelitis tuberculosa shows, on the contrary, the following conditions:

The amount of the urine is not especially increased. The color is dirty yellow, often brown-red from admixture of blood. It appears always turbid, and has a normal or diminished specific gravity and an acid reaction. The sediment is dirty yellow, often brownish and flocculent.

The excretion of normal constituents is not essentially altered.

Of the abnormal constituents, albumen is found in from 0·1 to 0·5 per cent., always far in excess of the corresponding pus and blood in the sediment. Blood-coloring matters are likewise provable in small amount.

The sediment is brownish, flocculent, and consists chiefly of pus mixed with a small amount of blood. Besides this, we find kidney-epithelium and much molecular detritus mixed with bacteria, which are clotted together in spherical and cylindrical shapes.

The blood-corpuscles of the sediment are generally the expression of an ulcerative process in the kidney-pelvis, and appear in the night as well as the day urine in slightly varying amount; while in pyelitis calculosa the urine passed in the night or after bodily rest shows an appreciable diminution in the amount of blood-corpuscles. The passage of urine with pyelitis tuberculosa is not so painful, nor is micturition so frequent, as in pyelitis calculosa. Besides this, the usual symptoms of lithiasis are wanting.

Especially supported is the diagnosis of pyelitis tuberculosa, if one finds, without other assignable cause, swelling of the testicles with tense plastic exudation, scrofulous scars, swelling of the glands or other than the scrofulous osseous inflammations, and deep and difficultly healing rectal fistulæ, etc.

The prognosis is in every case unfavorable when there is accompanying tuberculosis. With tuberculosis of the genital apparatus, if it occurs in healthy and young individuals, there may be improvement, or even (for instance, after the extirpation of a tuberculous testicle) a relative cure.

With echinococci in the kidney we find at times an accompanying pyelitis, which can not be distinguished from the usual chronic form. Only when the echinococcal tumor has perforated the kidney-pelvis do we find the characteristic sacs in the sediment; further, single scolices with a double-hook arrangement or remnants of the same and single hooks. (Pl. VIII., A, 4.)

Pyelitis with Bilharzia hæmatobia is a manifestation of existing cystitis. We find the pyelitis in such cases complicated with profuse parenchymatous hæmorrhage. In the sediment, besides numerous blood- and pus-corpuscles, and kidney- and bladder-epithelium, we find also fibrine flakes which contain the characteristic eggs of Bilharzia hæmatobia in great quantity. (See Hæmaturia, p. 278). The urine is rich in albumen and dissolved blood-coloring matters.

The para- or perinephritis can not be recognized from the analysis of the urine, since the latter may appear normal in very high grades of the diseases.

2. *Hæmaturia.*

Hæmaturia in its strictest sense does not belong here, since it is but a symptom and no idiopathic disease of the urinary apparatus; but we believe that it should be here included, since it very often complicates the various diseases of the kidney, the kidney-pelvis, and the bladder, often proceeding from simple hyperæmia, so that one is not always in a position to recognize the primary disease. On the contrary, one has very frequently to content himself with the very general diagnosis, "Hæmaturia from unknown causes."

The hæmorrhages of the urinary apparatus may be divided according to their character into three classes:

a. Hæmoglobinuria (Vogel's hæmatinuria);

b. Parenchymatous hæmorrhage;

c. Profuse hæmorrhage from rupture of the larger vessels.

I. *Hæmoglobinuria* betrays itself by a reddish-brown, brownish-black, or at times lake-colored urine, which even after standing for hours deposits no red sediment of blood-corpuscles. It retains its homogeneous red-brown color, because the blood-coloring matters are in solution. The reaction is generally acid and the specific gravity lowered. The urine contains a great mass of hæmoglobine and methæmoglobine. In the sediment we find at times epithelial (hæmorrhagic) and molecular detritus, colored brown by the coloring matters of the blood.

II. *Parenchymatous hæmorrhage* exhibits a red-brown, often coffee-colored urine, which after long standing retains its homogeneous red-brown color, but which, however, deposits a sediment, though often very slight, colored red-brown by blood-corpuscles. It generally reacts acid, has a varying specific gravity, and contains in solution more or less altered hæmoglobine.

The sediment is characteristic of parenchymatous hæmorrhage. We find in it blood-corpuscles of various sizes. Often normal disk-formed corpuscles are seen, with a rather indistinct depression; they also appear roundish, spherical, and colored somewhat brown. Frequently they are quite colorless, without fluid contents, similar to small rings.

In the field we often observe, besides the greater spheres, corpuscles only half or a quarter the usual size, and still smaller, down to fine dust-particles.

These microcytes, which in the last few years have been seen so often in the blood of patients, are characteristic of parenchymatous hæmorrhages of the urinary apparatus, and have been recognized as such for a long time.

III. *Profuse hæmorrhage from the large vessels.*—In this case we find the urine colored dark reddish-yellow, or red, similar to venous blood. The reaction is usually neutral or alkaline, and the specific gravity is varying. The urine contains generally only traces of blood-coloring matters in solution; only when the urine is strongly alkaline from carbonate of ammonia—and this is but seldom—considerable blood-coloring matters are found in solution.

Usually such urine deposits its entire blood as a considerable bright-red sediment after a few hours, and then appears of a normal yellow color.

Albumen arising from blood-serum is always present in the urine. The sediment consists throughout of normal disk-form corpuscles, in size similar to those of normal blood. Sometimes there appear also in the sediment blood-clots of various shapes.

These three forms of hæmorrhage can occur as well from the bladder as from the kidney-pelvis and the kidney, and consequently one is not always fortunate enough to know exactly from what part of the urinary apparatus the hæmorrhage originates.

1. *The reaction* should be first considered for the differential diagnosis. We find usually that the urine accompanying hæmorrhage of the kidney is acid, and with hæmorrhage of the bladder it is alkaline. This, however, is not always the case; for these conditions only hold when the hæmorrhage is complicated with a purulent catarrh, either of the kidney-pelvis or of the bladder. Here, also, the reaction with litmus is not always to be relied upon; for, with a profuse hæmor-

rhage through bursting of one of the greater vessels, the alkalinity of the blood may overcome the acidity of the urine, and we may find, in spite of the fact that the hæmorrhage does not come from the bladder, an alkaline reaction. In like manner the urine might become alkaline from the internal use of alkalies or alkaline mineral waters. Or perhaps the pyorrhœa of the kidney-pelvis might be so profuse that the alkali of the pus-serum could overcome the acidity of the urine. In such cases we would have an alkaline reaction of the urine from hæmorrhages which had not their origin in the bladder.

On the other hand, it must not be denied that hæmorrhages do occur in the bladder where the urine shows an acid reaction. This appears constant when there is no purulent catarrh of the bladder, and when the hæmorrhage is not profuse.

The reaction of the urine with litmus alone is not sufficient for locating the hæmorrhage.

More important for this determination is the proof of a large amount of ammonium carbonate; for when this is present in quantity, the probability is great that the hæmorrhage is from the bladder, especially if at the same time crystals of ammonio-magnesium phosphates appear in the sediment. (Pl. IV., B.)

2. *The color* of the urine should have even more weight than the reaction with litmus. The older practitioners connected the red-brown and brown-black shades of the urine with kidney-hæmorrhages, and the bright-red color with hæmorrhages from the bladder; this, however, is not always the case. The brown, red-

brown, and brown-black tones of the urine arise from decomposed hæmoglobine (methæmoglobine), and can only occur in those cases where the blood has been intimately mixed with the urine for a long time, at the temperature of the body—i. e., within the urinary apparatus. We find usually such a condition with parenchymatous hæmorrhage; the blood mixes gradually drop by drop with the urine, the corpuscles remaining for a long time with a relatively great amount of fluid matters, the products of retrograde tissue-metamorphosis. By this intimate mixing the urinary constituents have time to exert their destructive influence on the blood-corpuscles, and finally to change the red hæmoglobine to the brown methæmoglobine.

For this reason parenchymatous hæmorrhages from the bladder (carcinoma of the bladder) also give to the urine the red-brown and brown-black color.

It is quite otherwise, however, with profuse hæmorrhage, caused by the rupture of large vessels (bladder-hæmorrhoids). In such cases, at one time a great quantity of blood enters the urinary apparatus, especially the bladder, and quickly distends it. The unusual distention is followed by immediate contractions of the bladder, micturition ensues, and blood is passed before the urine has had time to decompose the hæmoglobine.

Since bladder-hæmorrhages arise mostly through rupture of the vessels, and kidney-hæmorrhages, on the other hand, are mostly parenchymatous, the brown-red color of the latter and the bright blood-red color of the former are of value for the diagnosis.

3. *The specific gravity* of the urine has a diagnostic value, inasmuch as we find generally, from hæmorrhage of the kidney and kidney-pelvis, such a condition of the organs that polyuria ensues (pyelitis), in consequence of which the specific gravity is lowered, while with bleeding from the excretory passages there seldom arise diseases (cystitis) which cause polyuria; hence in the latter case the specific gravity is normal.

4. *Blood-coagula.*—The form of the clots when present in the urine sometimes shows with certainty the location of the hæmorrhage.

If the coagula are soft and have the color and consistence of freshly clotted blood, then they have not existed for a long time. If, however, they are without color or appear somewhat dirty yellow, they are of older date and have been retained in the urinary apparatus a longer time. Likewise short rod-shaped clots arise at times from the distended kidney-pelvis (Simon), and appear in the urine after hæmorrhage from the kidneys. These were formerly considered as concretions, and thought to consist of pure fibrin. (Heller.)

The coagula which occur long and rod-shaped indicate a hæmorrhage from the kidney, while the lumpy, torn, irregular masses should come from the bladder. Further than this, it must be emphasized that only the long and rod-shaped blood-clots afford a certain indication of the place of origin of the hæmorrhage. If such forms occur, the seat of the difficulty must be above the ureters, for the rod-shapes are caused by passage of the clots through the same. We have seen a case, where a man forty-nine years old, suffering from a palpable neoplasm of the right kidney (with hæmaturia), repeatedly passed blood-clots 10 to 15 centimetres long, as thick as a lead pencil. The irregular lumps are not very characteristic, for they may occur from the kidney-pelvis as well as from the bladder. Blood may also pass in a fluid state from the kidney to the bladder, and then coagulate.

Coagula are not constant in connection with hæmaturia. Parenchymatous and profuse hæmorrhages only seldom give rise to clots; consequently they occur most frequently when the bleeding arises from vessels of small calibre.

5. *The microscopic analysis* furnishes the greatest aid to the differential diagnosis of hæmaturia.

The so-called blood-cylinders (Pl. V., A) and the hæmorrhagically tinged kidney-epithelium are characteristic of parenchymatous kidney-hæmorrhage. In severe kidney-hæmorrhages, however (if they are from vessels of large calibre), we do not find them. It is very probable that kidney-epithelium, at least in single cells, is present in the sediment; but the great mass of blood present conceals these cell-forms, so that one sees nothing but blood-corpuscles under the microscope.

Bladder-hæmorrhages are often not characterized by any microscopic indications. At times we find in the sediment an increased amount of bladder-epithelium and crystals of ammonio-magnesium phosphate.

Having described the micro-chemical characteristics of hæmaturia (hæmorrhages of the urinary apparatus) in general, we will now mention those diseases which afford opportunities of observing them, and in every case where it is possible endeavor to furnish new grounds for diagnosis.

I. *Hæmoglobinuria* (with or without methæmoglobinuria) occurs with hæmophilia, scurvy, malignant intermittent fever, putrid typhus fevers, and especially with those diseases which are accompanied by a so-called dissolution of blood; also after inhalation of hydrogen arsenide, carbonic acid, and similar gases. It is also observed after the transfusion of animal blood. [Exposure to cold seems also to be the cause of hæmoglobinuria, especially in the so-called "paroxysmal" form.]

II. *Parenchymatous hæmorrhage* may, as already stated, come from the kidney (and its pelvis) or the bladder, or from the entire urinary apparatus.

a. Hæmorrhage from the kidneys, besides the above-mentioned cases, is found usually with hæmoglobinuria in the following:

1. Sometimes with acute febrile processes, especially with exanthemata, where the hæmorrhage represents at the same time a high degree of hyperæmia.

2. In the majority of cases of acute and chronic parenchymatous nephritis.

3. Regularly with atheromatous degeneration of the kidney-vessels.

4. With thrombosis of the renal veins, as in general cachectic conditions, puerperal fever, not seldom with

uterine and crural phlebitis (Cruveilhier, "Anatomie," Livre 36); further, in consequence of severe injuries of the kidney, at times along with traumatic nephritis; also from thrombosis produced by compression of tumors in the vicinity of the hilus.

With nurslings who suffer from enteritis there at times occurs a thrombosis of the renal veins. According to O. Pollak, one observes that after the termination of a diarrhœa children become icteric, a considerable diminution of the urinary excretion takes place, and in the sediment are found blood-cylinders, blood-corpuscles, and hæmorrhagic epithelium.

Further, kidney hæmorrhages are observed—

5. Constantly with renal calculi, although no severe pyelitis may be present. We find then in the sediment, besides blood-corpuscles of various sizes and kidney-epithelium, jagged crystals of uric acid or calcium oxalate.

6. With cancer of the kidney, besides the parenchymatous hæmorrhage, we find nothing striking. Cancer-cells and cancerous tissue we have not found in the sediment of the urine; still the possibility is not excluded that, if the cancer develops in the kidney-pelvis, we might find carcinomatous tissue in the sediment. In small children palpable tumors of the kidney as large as the fist are frequently observed, with no indications in the urine but a slight albuminuria. Hæmaturia is therefore not a constant but a very frequent symptom of new growths in the kidney.

7. With renal phthisis or with cheesy inflammation

of the kidney, the kidney-pelvis, and the ureters, we find in the sediment, besides microcytes, kidney-epithelium, pus-corpuscles, much molecular detritus, great quantities of vibriones and micrococci, and at times waxy cylinders, together with such as consist of vibriones and micrococci.

b. Hæmorrhage from the bladder is observed—

1. With stone in the bladder and with catarrhal ulcerations of its neck. The hæmaturia is of a lighter grade.

In both cases, however, small blood-corpuscles (microcytes) are not observed in the sediment. All are of normal size. If a complicating bladder-catarrh is present, the urine reacts alkaline, and in the sediment we find, besides blood- and pus-corpuscles, crystals of ammonio-magnesium phosphate and bladder-epithelium.

Hæmaturia from bladder-stone becomes worse by exercise. The patient, therefore, should rest in bed. The hæmaturia from catarrhal ulcerations, which occurs in the neck of the bladder usually after gonorrhœa, exhibits itself toward the close of micturition, when the sphincter vesicæ begins to contract.

2. With papilloma of the bladder and with carcinoma villosum arises also parenchymatous hæmorrhage from the papillary growth of the mucous membrane. In the sediment we find not infrequently beautifully recognizable necrotic cancer-tissue, which confirms the diagnosis. However, one single microscopic investigation of the sediment does not suffice, since the cancer-tissue is not voided at each micturition. (For further particulars see section on villous cancer of the bladder.)

c. Parenchymatous hæmorrhage from the entire urinary apparatus occurs—

1. Sometimes after the evacuation from a paretic or paralyzed bladder and after catheterization. If for several years, on account of a paralyzed bladder, a portion of the urine had been accustomed to remain in it after micturition, and suddenly the entire amount is drawn off by a catheter, there arises necessarily a hyperæmia *ex vacuo*, which becomes the more intense accordingly as the muscles of the bladder have become hypertrophied, rendering complete contraction impossible. Since also the secretory pressure in the kidney, which before was obliged to overcome the weight of the residual urine in the bladder, meets with no such resistance after catheterization, a parenchymatous hæmorrhage ensues.

2. Parenchymatous hæmorrhage from the entire apparatus, but especially from the bladder, is observed in Egypt as a consequence of Bilharzia hæmatobia. There arises embolism of the vessels of the mucous membrane caused by the eggs of the Distoma hæmatobium. In such cases we find in the sediment, as already mentioned, little blood-coagula which the microscope shows to be imbedded with the long oval eggs of these parasites.

III. *Severe hæmorrhages of the large vessels* occur only from new growths and a varicose condition of the neck of the bladder.

With new growths (villous cancer of the bladder) they only occur profusely when the cancer has existed for a long time and becomes ulcerated. With the so-called bladder-hæmorrhoids the bleeding takes place so suddenly and profusely that the patient after one or two days becomes quite anæmic. It takes usually only a few days to destroy a perfectly healthy condition. Such hæmorrhages may occur after several months or several years. In the sediment we find nothing but blood-corpuscles of normal size and character.

In diphtheritic and croupous processes in the bladder, such as occur in consequence of so-called blood-dissolution, we find also blood in the ichorous, putrid, and alkaline-reacting urine.

3. *Cysto-Pyelitis and Pyelo-Cystitis.*

By these terms we understand a purulent catarrh which at the same time has involved the pelvis of the kidney, the ureter, and the bladder. If the pelvis of the kidney is principally the seat of the disease, it is designated as cysto-pyelitis; if however the bladder is most involved, then the disease is called pyelo-cystitis. Whether pyelitis or cystitis predominates is determined by the prevailing characteristics of the disease.

If pyelitis prevails, polyuria is generally present, the urine has a neutral or slightly alkaline reaction, the specific gravity will be lowered, and the purulent sediment will not stick to the glass. Albumen is found in greater proportion than the contained pus warrants, and in the sediment we find (besides pus-corpuscles) kidney- and bladder-epithelium and isolated triple-phosphate crystals. The pus-corpuscles seem to be well preserved, and sometimes to be pressed together in cylindrical masses.

If, on the contrary, cystitis prevails, then polyuria is not present, and the urine reacts strongly alkaline and has a normal or slightly lowered specific gravity. The sediment is glutinous, and the alkaline pus sticks to the glass. Albumen is present in greater mass than corresponds to the contained pus. Carbonate of ammonium is present in considerable amount.

In the sediment we find the pus-corpuscles much swollen and a great abundance of triple phosphates; we also find isolated scales of kidney- and bladder-epithelium.

Cysto-pyelitis and pyelo-cystitis occur very frequently with stricture of the urethra, hypertrophy of the prostate, and with paresis or paralysis of the bladder.

From cystitis or from pyelitis arises very often, through contiguity, cysto-pyelitis or pyelo-cystitis. It even happens that cystitis alternates with pyelo-cystitis and pyelitis with cysto-pyelitis.

Cysto-pyelitis as well as pyelo-cystitis can be caused by all those noxious circumstances which bring about cystitis and pyelitis. (See sections on Cystitis and Pyelitis.)

The prognosis depends upon the ætiological indications and the severity of the prevailing disease.

C. *Forms of False Albuminuria.*

The false albuminuria differs from the true and from the mixed form, in that the albumen is always present in quantities corresponding to the contained pus or blood. The albumen found is that of the pus or blood-serum. If both suddenly disappear from the urine—for instance, a few days after the opening of an abscess in the bladder, or as happens after the bursting of a varix in the neck of the bladder—then the albumen also disappears from the urine.

From the foregoing we see that true albuminuria is only brought about by changes in the kidney, while the origin of the false is always in the excretory passages and bladder. During the diseases of the pelvis of the kidney, on account of the immediate contact with the kidney proper, a form of mixed albuminuria occurs, which we have previously alluded to. There remains much to be said concerning the diseases of the bladder and urethra, for these give rise to different forms of false albuminuria.

1. *Cystitis—Bladder-Catarrh.*

We distinguish a chronic and an acute bladder-catarrh, and with each of these three grades.

In bladder-catarrh of the first grade, the urine contains neither albumen nor pus, but simply a great increase of mucus, and possesses a slight acid reaction. In the second grade the urine reacts alkaline, contains albumen and pus, and has a glutinous greenish sediment. In the third grade we have a putrid viscous urine with a strongly alkaline reaction, containing much albumen, pus, and blood. This is followed by ulcerative processes in the bladder, often complicated with suppurative nephritis.

The urine from bladder-catarrh shows generally an alkaline reaction, and many practicing physicians diagnose this by the litmus test.

While this is generally true, there are also cases when with cystitis the urine gives an acid reaction. This is for the most part noticeable in freshly passed urine, which, however, becomes alkaline in a few hours.

a. Acute Bladder-Catarrh, first grade.

Conditions.—The amount of urine is not increased; it has a normal or dark wine-yellow color and is turbid. The specific gravity remains unchanged. The reaction is weakly acid, but in a few hours becomes alkaline. The sediment is considerable, but cloudy, not compact.

The normal constituents are unchanged.

Of the abnormal constituents, we find carbonate of ammonium in small amount; albumen is not present.

The sediment consists chiefly of an increased cloudy mucous secretion. Microscôpically we find mucus-corpuscles (young cells) and a small amount of bladder-epithelium. After a few hours we find also single crystals of ammonio-magnesium phosphate.

The acute bladder-catarrh of the first grade represents generally a partial disease of the mucous membrane, such as occurs with prostatitis after gonorrhœa, or after instrumental investigation of the bladder and urethra. In women with malpositions of the uterus such a bladder-catarrh usually accompanies menstruation.

b. Chronic Bladder-Catarrh, first grade.

This form is characterized by a wine-yellow, very turbid urine, with a normal specific gravity, and whose twenty-four hours' amount is not increased. The reaction when first passed is acid, but in a few hours changes suddenly to alkaline. The sediment is considerable and cloudy. Sometimes the urine, when freshly passed, with an acid reaction has a peculiarly strong urine odor. The turbidity does not settle, and consists in great part of bacteria.

The excretion of normal constituents is not altered.

Of the abnormal constituents, carbonate of ammonium is present in small quantity; albumen is not present.

The sediment consists mainly of an increased cloudy mucous secretion, with bacteria. Microscopically we find single mucus-corpuscles, and also bladder-epithelium. After a few hours we find single triple-phosphate crystals in the sediment.

Such urine is constant with persons who find themselves obliged to employ catheters for the passage of urine, as with hypertrophy of the prostate, paresis of the bladder, and similar hindrances to urination. This first stage of bladder-catarrh occurs without exception in old women who have borne many children, or have been subjected to circumstances which lead to diseases of the uterus.

c. Acute Bladder-Catarrh, second grade.

This differs from the first grade chiefly by the pus contained in the urine.

The urine has a dark wine-yellow color, and is turbid. The turbidity consists of mucus and pus, while in the first grade we only find mucus. The specific gravity is normal. The twenty-four hours' amount is not increased. The reaction of the freshly passed urine is alkaline. The sediment is greenish-yellow, and sticks fast to the glass.

The excretion of the normal constituent is only so much altered that a part of the urea has changed to carbonate of ammonium.

Of the abnormal constituents, albumen is present in amount corresponding to the pus contained in the sediment; ammonium carbonate is present in considerable quantity.

The sediment consists principally of an alkaline pus mixed with crystalline and amorphous earthy phosphate. Microscopically we find single blood-corpuscles, urate of ammonia, and much bladder-epithelium.

Such urine is found with hypertrophy of the prostate, after using the lithotrite on large and hard stones, after dilatation of strictures, after catheterization and other instrumental investigations; further, through continuity, with gonorrhœa and acute prostatitis; and finally, after catching cold, especially from exposure to cold and moisture. In women, an acute bladder-catarrh with pus is sometimes observed after operation on the uterus and vagina, with perimetritis and pericystitis, and after exhibition of cantharides, copaiva, and similar powerful drugs. Badly fermented new beer should also be enumerated as a cause.

d. Chronic Bladder-Catarrh, second grade.

Characteristics.—A turbid wine-yellow urine, the turbidity being caused by pus-corpuscles and bacteria, while in the chronic bladder-catarrh of the first grade it is occasioned by mucus and bacteria. The twenty-four hours' amount is not increased. The specific gravity is normal. The reaction even when passed is alkaline. The sediment is greenish-yellow and sticks to the glass.

The excretion of the normal constituents, as also in the acute catarrh, is only so much altered that a greater part of the urea has changed to carbonate of ammonium.

Of the abnormal constituents, we find albumen in the urine in amount corresponding to the pus in the sediment, and much carbonate of ammonium.

The sediment consists chiefly of alkaline pus mixed with crystalline and amorphous earthy phosphates. The pus-corpuscles are found greatly distended, their contour destroyed, and their nuclei coming out. Often we only find free nuclei, imbedded in a homogeneous, turbid, ground sediment, and besides these bacteria and single bladder-epithelium cells.

Often the pus is completely dissolved in a urine rich in ammonium carbonate, whereby the urine becomes sirupy and has a stringy consistence.

Such urine is found with hypertrophy of the prostate, paresis of the bladder, and with serious strictures and similar impediments to the urinary excretion.

e. Acute Bladder-Catarrh, third grade.

This grade embraces those processes which are designated as parenchymatous cystitis and pericystitis.

While we are unable always to diagnose these diseases by the investigation of the urine alone, it assists the diagnosis very materially, in that by the analysis we can not overlook a severe form of purulent bladder-catarrh.

If the amount of pus is very disproportionate, then we may suspect the discharge of a bladder-abscess.

The uroscopic indications are similar to those of acute bladder-catarrh of the second grade, with the exception that the purulent sediment does not stick to the glass and is mixed with blood in greater proportion. Albumen is present in larger amount than corresponds to the pus and blood contained in the urine.

f. Chronic Bladder-Catarrh, third grade.

This is a purulent catarrh complicated with ulcerative processes in the bladder.

The urine is of a dirty brown-yellow color, and has a cadaverous odor. The reaction is strongly alkaline. The turbidity proceeds from bacteria and blood- and pus-corpuscles. The specific gravity is lowered. The sediment is dirty yellow, and sticks to the glass.

The excretion of normal constituents is diminished.

Of the abnormal constituents, we find much albumen, blood-coloring matters, carbonate of ammonium, and sulphide of ammonium.

The sediment consists of alkaline-reacting pus mixed with blood and earthy phosphates. Microscopically we observe in large quantities bacteria, molecular detritus, and single cells of bladder-epithelium.

This process comes from paralysis of the bladder and high stages of prostatic hypertrophy. It is complicated by suppurative nephritis or pyelo-nephritis. The appearance of uræmia or ammonæmia then closes the scene.

Similar urine comes with tuberculous ulcerations of the bladder and with diphtheritis.

With croupous processes in the bladder, which sometimes occur with women, very large plates of reddish-white membrane are excreted with the urine, which consist of fibrine. They are often from the size of a half dollar to that of the hand.

Very often upon the passage of the urine cystospasmus is confounded with bladder-catarrh, because the symptoms of both diseases are very similar. The investigation of the urine alone can determine the differential diagnosis.

With vesical spasms the urine is generally clear, and in case of turbidity this arises from earthy phosphates which come down on excretion. The urine is moreover pale, and reacts weakly acid or neutral.

By the heating test the urine becomes turbid, for by this means the earthy phosphates and carbonates fall, which are again dissolved on addition of acetic acid. Sodium carbonate is also sometimes present.

Albumen, pus, ammonium carbonate, etc., in contradistinction to cystitis, are not present.

In the sediment we find calcium carbonate, crystalline calcium phosphate, and amorphous earthy phosphates. Triple phosphates and bladder-epithelium are wanting.

2. *New Growths in the Bladder.*

Since the hæmorrhages of the bladder and their ætiological conditions have been described in the section on hæmaturia, we will only allude to them in so far as they are in close connection with bladder formations.

The following growths are found in the bladder:

(*a.*) Simple fibrous polypi, which project into the cavity of the bladder; these are of rare occurrence.

(*b.*) Medullary sarcoma; also of rare occurrence.

(*c.*) Epithelioma.

(*d.*) Villous or vascular tumors.

1. *Fibrous polypi* cause simply a bladder-catarrh of the second grade, and only when ulcerated do we find blood in greater or less amount in the sediment.

No histological elements characteristic of this form of tumor are found in the sediment. We can not therefore diagnose this formation from the analysis of the urine.

2. *Medullary sarcoma.*—The same is true of medul-

lary sarcoma, except that in later stages it causes a bladder-catarrh of the third grade. The urine is at times greenish-brown, with a strongly putrid odor. In the sediment we find much molecular detritus, but otherwise no characteristic elements which serve for the diagnosis.

3. *Epithelioma* generally develops slowly, and sometimes occasions a bladder-catarrh of the second and sometimes of the third grade. The sediment is always more or less blood-colored.

The microscopic investigation develops oftenest (besides blood- and pus-corpuscles) numerous peculiar small epithelial cells, which now and then appear in such large quantity that their number seems to equal the pus-corpuscles.

The epithelial cells are small, round or oval, not dissimilar to kidney-epithelium. Sometimes they may be caudate, showing two or three small projections. The nuclei are frequently very large and brightly glistening, and several are visible in the same cell. Sometimes ten or twelve of these cells hang together and form an epithelial shred. (Pl. VIII., B.)

One is not justified in diagnosticating epithelioma from the appearance of the various cell-forms in the sediment. If, however, a suspicion exists as to its presence, it is greatly strengthened by the indications of the microscopic investigation.

4. *Villous or vascular tumors* can always be recognized from the investigation of the urine.

At times two kinds may be distinguished: 1st, the papillary growth (papilloma) of the mucous membrane; and 2d, villous cancer proper.

Parenchymatous hæmorrhages are common to both forms, which may be accompanied by a bladder-catarrh of the second or third grade. In the first case only, after the sloughing off of the papillary growth which has become necrosed, healing may take place; while in true villous cancer a cachectic condition arises, which soon carries off the patient.

The villous cancer consists of a more or less soft mass, which, being of the consistence of medullary tissue, appears to involve the back and under wall of the bladder, so that the thickening or tumor may be felt by introducing the finger into the rectum. Upon this tumor, forming at the same time its covering, the true cancerous tissue develops itself. This consists of dilated capillary vessels and a thinner or thicker layer of epithelium.

Papilloma of the bladder, on the contrary, is confined simply to the mucous membrane. We are unable to find a thickening of the bladder-wall or a tumor from rectal investigation.

From the fact that such a difference exists between these two forms of bladder-growth, the question arises whether we may not be able to diagnose them with certainty from urinary investigation alone. This, however, is not possible, because not infrequently papilloma of the bladder after a time passes over into villous cancer. Although there are some characteristic indications for the microscopic recognition of villous tissue, they are not sufficient to insure a correct differential diagnosis.

If we find beautifully constructed villous tissue in fine branches, with a very thin epithelial covering, we generally suppose that we have to deal with a papillary growth in the bladder. If, on the contrary, we find villous tissue with a thick epithelial covering, so that one can not distinguish the broadened vessels of the villus, we conclude usually that we have a villous cancer to treat.

These indications from the urine are, however, less weighty than the local proof of a swelling in the bladder-wall and the accompanying cachectic condition.

On account of the difficulty in separating these two forms of villous tumor of the bladder, it seems proper to treat them here as possessing characteristics common to both.

The urine shows the following characteristic indications with villous tumors:

The twenty-four hours' amount is not increased. The specific gravity is normal. The color of the urine, as with parenchymatous hæmorrhage, is red-brown to brown-black. The turbidity is due to blood- and pus-corpuscles. The reaction is generally, though weakly, acid. Only when the villous tumor begins to increase rapidly, and the accompanying bladder-catarrh causes a greater excretion of pus, does the urine possess an alkaline reaction. The sediment is fine and flocculent, brownish to brown-red in color, and contains reddish or flesh-colored little fibres or larger similar shreds.

The consistence of the urine is usually that of a thin fluid, though there occurs sometimes with villous tumors (but only temporarily) a fibrinuria with its peculiar gelatinous appearance. This is the only disease of the urinary organs in our latitudes in which even a transitory fibrinuria has been observed.

The urine when freshly passed appears as a thin fluid; but in a few minutes it suddenly stiffens to a jelly-like mass, which can scarcely be poured from the vessel. After long shaking the urine again becomes fluid, and may be used for further investigation. The color of the urine with fibrinuria is not always intensely bloody, but sometimes only slightly reddish yellow.

Fibrinuria (with villous tumor) is always accompanied by sevère strangury. One can easily understand that with strong spasmodic muscular contractions of the bladder a compression of the blood-vessels penetrating the muscular layer follows. Since the veins, because of the thinness of their walls, are more compressible than the arteries, there must arise a stasis in the vessels of the villous tumor. If the tension is very great in the vessels, a rupture of them may occur, and hæmorrhage into the bladder ensue. If, on the other hand, the tension is not sufficient to rupture the vessel-walls, then the plasma exudes from the capillaries, and coagulates after the excretion of the urine because of the contained fibrine.*

---

* Such a fibrinuria caused by severe strangury has been observed by us in three cases.

The excretion of normal matters with villous tumors is not altered.

Of the abnormal constituents, albumen and blood-coloring matters are found in considerable quantity. It is especially to be remarked, that with villous tumors there is always more albumen in the urine than corresponds to the amount of pus or blood in the sediment. This condition depends upon the increased tension within the supplying vessels of the villous tissue.

Since these appearances, accompanied at the same time by an acid reaction of the urine, are very similar to the indications of true albuminuria, one must be extremely careful in such cases not to diagnose a kidney-affection without having distinctly recognized kidney-cylinders in the sediment. This precaution is the more necessary, as the inexperienced may easily confuse single delicate villous shreds with kidney-cylinders.

Ammonium carbonate is not always provable.

The flocculent sediment is usually brownish, with severe bladder-catarrh dirty yellow, and with profuse hæmorrhage after rupture of a blood-red color. The more blood or pus the urine contains, the more difficult it is to recognize the characteristic tissue-fibres which at times are very sparingly present. With profuse hæmorrhage especially it is only an accident if in the great amount of blood one finds a characteristic lump. With a purulent sediment one must also be very careful, although the red lumps or flakes are much easier to be found in the greenish pus than in the dark blood. We therefore choose a comparatively clear and less bloody urine for the search for villous tissue. After the sediment has sufficiently settled, it should be emptied upon a watch-glass, and the red flakes removed on a needle or pincette and placed under the microscope.

The chief constituent of the sediment is blood alone, or blood mixed with pus. The blood comes mostly in a fluid state, though frequently we observe clots of various sizes in the sediment. These are distinguished from villous tissue by the fact that they appear dark black-red, while the latter are usually flesh-colored. Often, however, we find villous tissue inclosed in the clots of blood. The blood-corpuscles show the same forms as in parenchymatous hæmorrhage; we find them of various sizes and spherical shape (microcytes).

Villous tissue appears in various forms, according as the urine possesses an acid or alkaline reaction. It is an error to suppose that the villous tissue appears as beautiful and unchanged as is generally represented in the text-books. An unchanged representation of the living villous tissue never occurs in the sediment. Such can, however, be observed when accidentally a small fragment of the fresh growth has been detached and brought out in the orifice of the catheter. Usually only necrotic villous tissue is perceived, and this under the microscope may appear in numerous forms. These become necrotic and are cast off by the bursting of vessels in the villus.

In the commencement of the disease we find the most perfect villous tissue. We observe then not infrequently, under the microscope, a small shred-like structure, from which the tissue extends similar to the fringe of a napkin. The thinner the epithelial covering, so much more distinctly are seen the villi. Since the necrotic villi and their vessels are for the most part ruptured, we find but seldom unaltered blood-corpuscles in the lumen of the dilated tubes. Beautiful villous tissue is found especially with papillary hypertrophy of the mucous membrane of the bladder. (Pl. VIII., B.)

One is not always so fortunate in his investigations; for, especially with the proper villous cancer, having a thick epithelial covering, it is very difficult to find distinct villi. The epithelial covering of the necrotic villi is in a state of molecular disintegration, so that the divisions of the single cells are no longer apparent. It is infiltrated with blood- and pus-corpuscles and teeming with bacteria. Sometimes one sees in this molecular mass true branching forms which show the ground-structure and blood-vessels of the villous tissue.

Although histologically in such cases we have no characteristic points for recognizing true villous tissue, yet there are other very important microscopic data which confirm the diagnosis of the same. They are as follows:

Under a high power of the microscope, if one examines the necrotic tissue, we find single spots of the epithelial covering colored brownish. On examining these spots more carefully, we observe, if the urine possesses an acid reaction, beautiful yellow or brown rhombic plates of hæmatoidine, and yellow grassy forms which consist of the same coloring matter. If we permit a drop of HNO_3 (fuming) to flow under the cover-glass, then we observe under the microscope that the brown-yellow spot, and even the entire necrotic villous tissue, becomes successively green, blue, and violet. Hæmatoidine is a characteristic proof of old hæmorrhagic tissue, and is to that extent of diagnostic significance for bladder-cancer.

In such necrotic pulpous tissue not seldom peculiar crystals are found, which, as we learn from better preserved specimens, are peculiar to villous tissue, and are found in the urine only in connection with it. These are small, colorless, round rosettes, which are only soluble in concentrated acids and alkalies, and that without evolution of gas. Diluted acetic acid does not alter them. They consist most probably of oxalate of calcium, since they effervesce actively upon addition of acids after strong heating. These supposed calcium-oxalate crystals we find, as before stated, only in the parenchyma of villous tissue, and only in acid urine.

If the urine is strongly alkaline, and a considerable purulent bladder-catarrh is present, we find the necrotic tissue perfectly incrusted with earthy phosphates and ammonium urate. The patient has a distinct sensation as if sand had passed the urethra, and generally desires an examination for stone.

On examining the soft parts of these incrusted flakes, we find them to be infested with bacteria, accompanied by homogeneous structures, groups of fine needle-formed crystals (crystalline phosphate of lime), and large crystals of ammonio-magnesium phosphate and urate of ammonium. Sometimes in this incrusted flake we may find a portion of the hard groundwork of villous cancer.

3. *Bladder-Stone.*

If a stone is present in the bladder, we generally find blood in the urine after strong bodily exertion, which disappears after a long rest. With stone the day urine is consequently accompanied by more blood than the night urine. In this characteristic it differs from other forms of hæmaturia, in which the mixture of blood is constant at every evacuation.

Bladder-stones frequently set up a bladder-catarrh. If the stones are small and have a smooth surface, i. e., stones consisting of uric acid, then we find only a bladder-catarrh of the first grade. If, however, the stone is larger or has a rough surface (oxalate, phosphates), we then find a purulent bladder-catarrh of the second grade. The hæmorrhage will be more severe, as the stone is rougher upon its surface.

When there is present a smooth stone, the reaction of the urine is usually acid. If, however, a profuse purulent catarrh accompanies the stone, the reaction will be alkaline.

It is important to consider whether a kidney-affection or pyelitis exists in complication with the bladder-stone, since it may be the case that, besides the stone in the bladder, we may also find concretions in the kidney-pelvis. We have then the indications of cysto-pyelitis with hæmorrhage. (See the section on Mixed Albuminuria.)

The determination of the chemical constitution of the stones depends upon the chemical constituents of the urine; for the crystalline and amorphous forms in the sediment constitute the outer layer of stone. The kernel in most cases consists of uric acid, since, in our experience, of 100 bladder-stones 90 per cent. contained the uric-acid kernel.

4. *Diseases of the Urethra and Prostate.*

These do not essentially change the character of the urine. With acute and chronic prostatitis, and also with hypertrophy of the prostate, occurs usually a bladder-catarrh of the first and second grades as a complication. To the acute and chronic prostatitis is added generally a bladder-catarrh of the first grade; to hypertrophy of the prostate, corresponding to the retention of urine, sometimes a chronic bladder-catarrh of the first and sometimes of the second grade. With prostatic hypertrophy of high degree, usually spermatozoa are found in the urine. It appears that the growing glandular tissue presses upon the muscular walls of the ductus ejaculatorii, and thereby allows the escape of the spermatic fluid.

With *spermatorrhœa* the urine is generally neutral or alkaline. It becomes cloudy on heating, and the precipitable earthy phosphates fall and dissolve upon addition of acetic acid (Heller's bone-earths). Albumen is not present. In the sediment we find, besides numerous spermatozoa, calcium-carbonate and calcium-phosphate crystals, and sometimes also ammonio-magnesium phosphate. In the urine after the escape of semen we constantly find spermatozoa; it is therefore very important, before a diagnosis of spermatorrhœa is made, to ascertain whether passage of the urine brought for examination has been immediately preceded by a pollution or coition.

With acute and chronic *gonorrhœa* we find in the sediment pus-corpuscles and single cylindrical epithelial cells from the urethra. Albumen, however, is not provable in the urine.

Should it be doubtful whether the purulent sediment of the urine arises from the urethra or a higher portion of the urinary tract, the patient should (according to Thompson) urinate into two vessels. The first half of the evacuation would contain the pus from the urethra, while the second portion would contain only the catarrhal secretion of the bladder or the kidney-pelvis.

The so-called gonorrhœal threads which almost constantly appear in the urine of gonorrhœa, even after normal healing, are usually catarrhal secretions from the ducts of the accessory glands of the urethra. Only the very long threads, which are seldom found, are formed in the urethra itself.

Two kinds of gonorrhœal threads may in general be distinguished. The first are thicker and longer, and have not infrequently a knob-like swelling on the end.

These arise usually from the pars prostatica urethræ. The second are thin and short, and show no knob-like swelling. These arise generally from Littré's glands of the urethra.

Such a thread under the microscope is seen to consist of pus-corpuscles, mixed with small cylindrical epithelial cells imbedded in a homogeneous ground-substance. (Pl. VI., A, 2.)

With *croup of the urethra* appear small and white, filmy or tube-formed structures, mixed with pus and blood. These consist of fibrine, and are washed out by the stream of urine.

DR. ULTZMANN'S SACCHARIMETER

FOR PRACTICING PHYSICIANS AND STUDENTS.

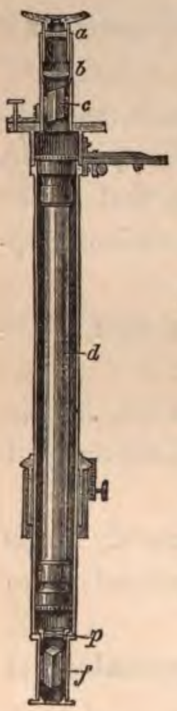
The high price and complexity of the polarization apparatus generally used induced me to request of Herr Reichert a saccharimeter adapted for use with a microscope-stand, and in accordance with a design of my own. He cheerfully undertook the task, and has constructed a very useful instrument. The principle, importantly modified in its application, is that of the Mitsherlich apparatus, which has been so variously applied by physicians.

The great advantages of this instrument over others are:

1. No artificial source of light is needed, for the concave mirror of the microscope-stand brilliantly illuminates the field of vision.
2. The apparatus itself is small (it is scarcely longer than the fully elongated tube of a medium-sized microscope) and needs no separate stand.
3. By means of this instrument the percentage of sugar can be directly calculated.
4. The entire apparatus can be had for a comparatively very small cost.

After three years' experience with it, during which time I have had the opportunity of analyzing many diabetic urines, I can at present say that this instrument, in its latest form, answers all the requirements of the practicing physician, and I can therefore most highly recommend it.

In using the apparatus, the tube, objectives, ocular, etc., of the microscope are withdrawn, and in their place the saccharimeter is inserted and made fast to the stand by means of a small screw.* The concave mirror is then turned into position, and by looking through the instrument it is determined whether or not it is properly adjusted.



In the accompanying figure *a* is the biconcave and *b* the objective lens of a small Dutch telescope, the focal distance of which extends to *p*; *c* is the upper Nicol prism, with which a vernier is closely connected; *d* is a glass tube for holding the suspected fluid, which should be filtered or otherwise cleared up before analysis; *p* is a double plate of right and left rotating quartz; and *f* the lower Nicol prism.

The arc [fixed scale] is so divided that one division of it represents one per cent. of grape sugar at a temperature of

---

* The stands most used in Vienna are Reichert's No. III. and Hartnach's No. VIII., but the saccharimeter may be attached to any stand.

20° C. By means of the vernier, *tenths of a degree* (i. e., *of one per cent.*) can be very approximatively determined. Since ten degrees of the vernier correspond exactly with nine degrees of the arc, to the percentage of sugar found must be added as many tenths as spaces are counted on the vernier up to that division which exactly coincides with a division of the arc.

If, for example, the zero point of the vernier does not quite reach (toward the right) the five-point of the scale, it indicates that the percentage of sugar is more than *four* and less than *five per cent.* If it be desired to estimate *the tenths per cent.*, and the *sixth* division of the vernier is the first (counted from the zero point) to coincide with a division of the arc, then *six* is the number of *tenths* required, and the apparatus would indicate in this case 4·6 *per cent.* grape sugar present.

In estimating the strength of cane-sugar solutions, it is to be borne in mind that the polarization power of cane sugar is three quarters that of grape sugar.

Both the above-mentioned kinds of sugar turn the polarized ray to the right, albumen (i. e., serum-albumen), on the contrary, toward the left, and as far toward the left as grape sugar toward the right.

If the glass tube of the saccharimeter is empty, or contains a fluid holding in solution substances having no optical influence (for example, normal urine), the zero point of the vernier coincides exactly with the zero point of the scale, and the two halves of the field of vision are exactly isochromatic.

If, on the contrary, an optically active substance is contained in the fluid (as, for example, sugar), the normal isochromatism of the two halves disappears, and a distinctly unequal coloring takes place. This is the more apparent the greater the amount of optically active substance present in solution. When this unequal coloring occurs, the vernier is to be moved toward the right or left (according to the presence of sugar or albumen) until the color of the two halves is again exactly the same. The percentage is then read off the scale in the way above mentioned.

If a diabetic urine is very light colored and clear, it can at once be put into the glass tube of the instrument and the determination made. If, however, it is dark and cloudy, and contains albumen, it is advantageous to first clarify it and remove all disturbing substances. This is best accomplished by means of a ten per cent. aqueous solution of sugar of lead. The lead acetate causes in urine a copious white precipitate, consisting of lead chloride, phosphate, and sulphate, and the precipitate carries down with it all the coloring matter of the urine and such albumen as may be present. If the urine is then passed through a dry filter, the resulting filtrate is almost as clear as water, and is particularly well adapted for the apparatus. Since, however, the amount of sugar in the mixture (after the addition of the lead-acetate solution) differs from that in the urine, the amount of dilution must be taken into account in estimating the sugar present. It is best, therefore, to take 75 c.c. of urine, and to that add 25 c.c. of lead-acetate solution, shake, and filter. In estimating the sugar present in the urine, one quarter of the percentage of the mixture added to that percentage will give the percentage of sugar in 100 c.c. of urine. In other words, the percentage of the mixture is three quarters that of the urine.

For example, if to 75 c.c. of a dark, albuminous saccharine urine have been added 25 c.c. of lead-acetate solution, the mixture filtered, and found to contain 4·8 per cent. sugar, then 1·2 per cent. must be added to give the percentage in 100 c.c. of urine, which would, therefore, contain 4·8 + 1·2 per cent. = 6 per cent. sugar.

In filling the glass tube, care must be exercised that no air bubbles are included in the fluid. It is well, therefore, to fill the tube as full as possible and push the glass cover on from one side before screwing on the top.

[We have used the above-mentioned instrument for several months, and find it gives results agreeing within a small fraction of a per cent. with those given by Fehling's test with artificially prepared solutions of glucose in distilled water and urine, and with diabetic urine. In the latter case the sugar must be present in more than one per cent. to give satisfactory results. In using it one should look but a few seconds at a time and make several observations.—TRANSLATOR.]

APPENDIX A.

ALBUMEN.

In view of the large amount of literature recently published concerning albuminuria, the addition of a few words, supplementary to the text, would seem desirable.

With the increased delicacy of our tests, and the greater attention paid to the subject, albumen is now frequently detected where formerly it would have been overlooked. Thus, hundreds of cases have recently been reported, and by numerous observers, where albuminuria has been found, and in at least a large number of these cases the individuals were apparently healthy. For instance, Prof. Grainger Stewart found albuminuria in 31 per cent. of 407 persons in apparent health; and Dr. G. R. Shepherd, in a collated total of 35,000 examinations for life-insurance and other purposes, reported albumen found in 2 per cent.; while Posner asserts, as the result of his investigations, that serum-albumen is constantly present (in small quantity) in normal urine. Unfortunately, the kind of albumen found has not always been stated, although it has usually been serum-albumen or globulin.

According to the chief characteristics of the different varieties of albuminuria observed, various titles have been proposed for them: thus we have "cyclic," "paroxysmal," "intermittent," "simple persistent," "dietetic," and "physiological" (*sic!*). Dr. C. H. Ralfe advocates the use of the term "functional" to include these varieties, and defines as "functional albuminuria" that form "which is not dependent upon structural disease of the kidneys, or proceeding from morbid conditions of the urinary passages." This term, although not new and not unobjectionable, would seem to be a convenient one; at least, until the physiology and pathology of albuminuria are better understood.

We now know that albumen appears in the urine after severe muscular exercise, excessive mental work, cold bathing, and even ingestion of food (especially in the case of dyspeptics) or rising from bed; and while in many of the cases reported there may have been hyperæmia or structural disease (unrecognizable) of the kidney, yet in others it seems necessary for us to assign the condition to "faulty metabolism," or confess our ignorance as to its causation.

What especially concerns the practitioner, however, is the fact that simply the occurrence of albuminuria does not warrant a grave prognosis or even rejection for life-insurance. Of more importance than its simple presence is the persistence of the albumen in the urine, its approximate amount (in functional albuminuria it is usually 0·1 per cent. or less), its accompaniments (especially casts, cells, etc.), and its probable origin.

The two following tests—highly commended by some urine-analyzers—are appended:

The Nitric-Magnesian Test was suggested by Dr. Roberts, and consists of one volume strong nitric acid and five volumes saturated solution of magnesium sulphate. Owing to its specific gravity (1240), it is used by the contact method. It is claimed for this test that it is equal in delicacy to the mercuric iodide and phenic-acid tests, and acts as does nitric acid with albumen, mucin, and peptone. It is less corrosive than pure nitric acid, but can not be used with urine clarified by liquor potassæ.

The Phenic Acetic Acid Test was suggested by Millard, and is claimed by him to be as delicate as the foregoing. It behaves toward mucin, peptone, and the alkaloids as do the potassio-mercuric iodide and picric-acid tests. Its composition is ac. phenic (glacial), 95 per cent., ʒij; ac. acet. pur., ʒvij. Mix, and add liquor potassæ, ℥ij ʒvj.

APPENDIX B.

SUGAR.

The Phenyl-Hydrazin Test.—The use of phenyl-hydrazin hydrochlorate as a test for sugar in the urine was first suggested by Dr. Emil Fischer, of Erlangen, and has been advocated abroad, especially by Drs. von Jaksch, Ultzmann, and Grocco, and in this country first by Dr. A. K. Bond, of Baltimore.* It depends upon the formation of a crystalline substance, "phenyl-glucosazon," when to a solution of glucose the phenyl-hydrazin salt is added in the presence of an excess of sodium acetate.

Ultzmann's method of using the test, slightly modified by Bond, is the following: Into a test-tube five inches long pour the phenyl-hydrazin salt (a dry, crystalline, bran-like substance) to the height of about four tenths of an inch; add powdered crystals of sodium acetate to the same height above, and urine to one half the height of the tube (Ultzmann first removes albumen if it be present). This gives approximately by weight one part phenyl salt, two parts sodium acetate, and fifteen parts urine. Shake the tube gently until the sodium acetate is dissolved, and then boil carefully for half a minute; set the tube aside, and examine for crystals. If sugar is present, there will be deposited yellow, needle-like crystals, having a strong tendency to form clusters or sheaves. These crystals melt at a temperature of 204° C., and are distinctly visible macroscopically if much sugar is present. The time required for the deposition of the crystals varies proportionally with the amount of sugar present. If there is a large quantity, fifteen minutes may suffice; if a very small quantity, forty-eight hours may be required. Whether the crystals are visible macroscopically or not, the sediment should be examined with the microscope (a power of two hundred diameters amplification is sufficient), when, amid the red globules caused by excess of the phenyl salt, will be seen beautiful needle-like crystals, in clusters, should the urine contain sugar.

---

* "Medical News," August 6, 1887, and "Baltimore Underwriter," September 20, 1887.

It is claimed for this test that it does not react with normal urine; that it detects sugar in as small quantity as does Fehling's test; and that it reacts with all substances of the sugar class which reduce alkaline copper solutions; thus it reacts with glucose, levulose, lactose, cane-sugar, maltose, and sorbin, but not with inosite or trehalose. Of these substances, however, levulose and lactose are the only ones occurring in urine which can be confounded with glucose, and levulose rarely occurs without glucose, while lactose only occurs in the urine of pregnant or nursing women. This reagent does not spoil by keeping, and its mixture with urine being antiseptic, allows the crystals formed to be detected weeks after their precipitation. If all claims made for it be confirmed by continued trial, it will be perhaps our most satisfactory qualitative test for sugar.

The following new tests for sugar have been advocated by H. Molisch:* Take 0·5 to 1 c.c. of urine and add to it 2 drops of a 15 to 20 per cent. alcoholic alpha-naphthol solution, and an excess of concentrated sulphuric acid; shake, and, if sugar is present, a deep violet color is developed. On dilution with water, a violet-blue precipitate occurs, which is soluble in alcohol and ether, with a yellow, or in potassium hydrate with a golden-yellow color. If thymol be used instead of alpha-naphthol, a deep-red color is produced, and upon dilution with water a carmine-red, flocculent precipitate, soluble with a pale-yellow color in alcohol, ether, and potassium hydrate, and with a bright yellow in ammonium hydrate. Most kinds of sugar, except inosite, and most glucosides, respond sooner or later to these tests. Indican does not. Urea, creatinin, xanthin, uric acid, allantoin, hippuric and succinic acids, phenol, and pyrocatechin give negative results. Molisch considers these the most delicate tests, however, and claims that they will detect 0·00001 per cent. of sugar. Normal urine responds to these tests when diluted with 300 volumes of water.

To distinguish normal from diabetic urine he recommends the following: (1) Dilute a specimen of normal and one of suspected urine with 100 volumes of water, and compare the colors resulting from the application of the the tests. (2) Dilute two similar specimens with 400 volumes of water; the diabetic urine will still respond to the test, while the normal will not.

---

* "Boston Medical and Surgical Journal," vol. cxvi, No. 15, p. 354.

Seegen carefully examined these tests, and found that sugar in 0·05 per cent. gave both reactions distinctly. Solutions containing 0·01 per cent. gave with thymol a dark sherry-yellow color, and with alpha-naphthol a faint violet tint; but on dilution with water no precipitate was formed. Normal urine reacted, as described by Molisch, but on dilution with 100 volumes of water there was no precipitate. Various animal substances and secretions and chemically pure albuminous bodies, as peptone, egg-albumen, serum-albumen, and casein, also gave the same reactions. He therefore regards these tests as less delicate than Trommer's, and as of no value as tests for sugar alone.

Molisch responds that these tests are more delicate than Fehling's solution, although with dilute solutions of sugar solid alpha-naphthol should be used instead of the solution. The albuminous bodies, he claims, give results somewhat resembling those with sugar, but the precipitates obtained upon dilution with water are of a different color (dirty-yellow or yellowish-brown), excepting that with peptone, from those with sugar. Hydrochloric acid also will dissolve these precipitates with a carmine-red or reddish-violet color, while the precipitate obtained with the sugar solutions is insoluble in this acid. In place of sulphuric acid, hydrochloric acid may be used in these tests, the mixture being subsequently boiled for a minute. Fibrin, vitellin, serum-albumen, egg-albumen, and peptone do not give the reaction when hydrochloric acid is used. Normal urine gives the reaction when boiled with alpha-naphthol and hydrochloric acid, even if diluted ten times, and he therefore considers that it must contain sugar or some body as yet unknown.

The experiments of Wedenski* and Udránzky† tend to prove the constant presence of glucose, or at least a carbohydrate, in the urine, and the latter states that the alpha-naphthol reaction of Molisch simply proves the presence of carbohydrates, but does not differentiate between them.

---

* "Zeitschrift für physiol. Chem.," xii. Bd., S. 122.

† "Zeitschrift für physiol. Chem.," xii. Bd., S. 377.

APPENDIX C.

NEW REDUCING SUBSTANCES.

DR. ROBERT KIRK[*] describes a new acid, which he found in the urine of three brothers, and which gave the reactions of Boedeker's alkapton. It reduced copper but not bismuth salts, and readily oxidized in the presence of an alkali. The urine containing it took on a dark color from the surface down on exposure to air. The acid ethereal extract of the urine deposited crystals of the acid in question, and they occurred in the form of long, thin prisms, with oblique ends, sometimes collected in stellate or sheaf-like clusters. The substance resembled glycuronic acid in some of its relations, and seemed closely related to pyrocatechin and protocatechuic acid. He proposed to call it "urrhodinic acid." Its pathological significance is not known.

An interesting case occurred in the practice of Dr. Frank Donaldson, Sr., of Baltimore, the urine of which was independently examined and reported upon by Drs. John Marshall[†] and T. Barton Brune.[‡] The patient was apparently healthy, but had been repeatedly rejected by life-insurance examiners, on account of supposed glycosuria. His urine was perfectly clear and without sediment. On standing several hours it became first a reddish-yellow; later, a brownish-red from the surface downward. It gave a port-wine red, later, an almost black color, with sodic hydrate. Nitric acid almost decolorized the fluid, but evolved no caramel odor. The substance produced a brown color in the supernatant fluid with Boettger's test, but did not reduce the bismuth salt. It gave a light violet color with thymol and sulphuric acid. It gave no appreciable reaction with polarized light; it did not ferment, and, according to Dr. Bond, did not react with phenylhydrazin hydrochlorate. It did, however, reduce copper salts, and gave the sugar reaction with Johnson's picric-acid test. With ferric chloride it gave a faint-green precipitate. Both Drs. Marshall and Brune isolated the substance in crystalline form, by methods described in their articles. Its crystals were opaque, needle-shaped prisms, arranged in groups radiating from a center. They melted at 140° C. Dr. Marshall found it to be an acid, and proposes the name of "glycosuric acid" for it. Possibly it is identical with Kirk's "urrhodinic acid"; apparently it is a phenol derivative.

---

[*] "British Medical Journal," November 17, 1886.

[†] "Medical News," January 8, 1887.

[‡] "Boston Medical and Surgical Journal," December 30, 1886, and January 27, 1887.

Leo,* after removing all the ordinary reducing substances, such as uric acid, creatinin, coloring matters, etc., found, in three out of twenty-one cases of diabetes, a new substance belonging to the sugar series and isomeric with glucose. It reduced strongly copper-oxide solutions; was lævogyrate and non-fermentable. He did not find it in normal urine, and no name has been proposed for it.

---

* "Deutsche med. Wochen.," 1886, S. 869; and Virchow's "Archiv," Bd. 107, S. 99.

Leube* found in the urine of a patient having osteomalacia, cystitis, and nephritis, a new coloring matter, which turned the urine a dark violet to brown color on exposure to air (i. e., oxidation), and gave a brown, later, yellow color with alkalies. It gave characteristic spectroscopic appearances.

In addition to the substances above mentioned, the following, when introduced into the system, form compounds or derivatives in the urine which have the power of reducing alkaline copper solutions, viz., turpentine (as mentioned in the text), chloroform (unchanged), benzoic and salicylic acids (the sodium salicylate derivative also reacts with potassium picramate), copaiba, hydrochinon, phenol, benzol, tannic acid, glycerin, and ortho-nitrotoluōl (Laache), cubebs and camphor (glycuronic acid being formed). The glycuronate of potassium also forms crystals with phenyl-hydrazin hydrochlorate, but they melt at 114° to 115° C.

Some of these substances are also active toward polarized light: thus, glycuronic acid is dextrogyrate, while the copaiba derivative is lævogyrate. The turpentine compound seems also to be fermentable.

The occurrence in urine of such bodies as these, and others before mentioned, emphasizes the propriety of questioning the patient as to his ingesta, and the necessity for using more than one test in examining for sugar.

---

* "American Journal of the Medical Sciences," vol. xciv, p. 545.

APPENDIX D.

BLOOD.

The Almén-Schönbein Test for blood in urine is highly commended by Laache* as very delicate and reliable. Its simplicity recommends it to physicians. To perform it, proceed as follows: Mix 1 c.c. of freshly prepared tincture of guaiacum with an equal volume of ozonized oil of turpentine (i. e., oil of turpentine which has been exposed to the atmosphere for a long time), and pour the mixture carefully down the side of a reagent glass upon the surface of the suspected urine; the reagent will float upon the urine, and immediately between the two fluids will occur a resinous precipitate in the form of a grayish-white (later, dirty-yellow or green) layer, and directly above it, if blood is present, a beautiful indigo-blue ring, which will contrast sharply with the nearly colorless supernatant fluid. Upon shaking the contents of the glass, a clear blue emulsion, will result.

Mahomed's test, and Stevenson's modification of it, are based upon the same reaction, ozonic ether being used instead of oil of turpentine. Saliva, nasal mucus, and a salt of iodine occurring in the urine of those taking iodide of potassium, are said to cause a similar reaction (Tyson).

---

* "Harn-Analyse," S. 91.

ALPHABETICAL INDEX.

A

PAGE
Abnormal Constituents........ 84
Acetonæmia.................. 122
Acetone..................... 121
Accidental Constituents....... 143
Acid Albumen................ 94
Acidity............. 46, 201, 270
Albumen............. 91, 84, 215
  Nitric Acid Test for......... 88
  Nitric Magnesian Test for.... 308
  Boiling Test for............ 89
  Metaphosphoric Acid Test for 102
  Phenyl-Acetic Acid Test for. 308
  Potassium Ferrocyanide Test for.................. 102
  Sodium Tungstate Test for... 102
  Potassio-Mercuric Iodide Test for.................. 99
  Picric Acid Test for......... 100
Albuminuria................. 242
  False..................... 280
  Mixed..................... 258
  Functional................. 86
Alkali-Carbonates............ 144
  -Chlorides................. 73
  -Phosphates................ 80
  -Sulphates................. 82
  -Urates.................... 151
Alkapton.................... 106
Allantoin.................... 55
Ammonio-Magnesium Phosphate 164
Ammonium Carbonate........ 140
  Urate..................... 153
Amyloid Kidney............. 255

PAGE
Anuria...................... 234
Apparatus................... 198
Approximative Analysis....... 224

B

Bacteria..................... 179
Bilharzia............ 186, 267, 278
Biliary Acids................. 136
  Pettenkofer's Test for....... 136
  Oliver's Test for............ 138
Biliary Coloring Matters....... 131
  Gmelin's Test for.......... 131
  Heller's Test for............ 132
  Ultzmann's Test for......... 133
  Marechalt's Test for......... 134
Biliprasine.................. 131
Bilirubine................... 131
Bladder...................... 27
  New Growths in............ 288
  Polypi in.................. 288
  Medullary Sarcoma......... 288
  Villous Tumors in.......... 289
  Epithelioma of............. 289
  Stone in.................. 297
Blood....................... 273
  Corpuscles................. 171
  Coloring Matters........... 128
  Tests for.................. 317

C

Calcium Carbonate............ 185
  Oxalate.................... 155
  Phosphate.................. 77
Cancer Elements............. 184
  Villous.................... 289

PAGE
- Casein ... 94
- Casts and Cylinders ... 173
  - Fibrine ... 174
  - Granular ... 175
  - Hyaline ... 176
  - Waxy ... 176
  - Epithelial ... 177
  - Uric Acid ... 178
  - Bacterial ... 178
- Chemical Composition ... 48
- Chlorides ... 73
- Chlorine ... 219
- Chlorosis ... 238
- Chyluria ... 161
- Cloudiness ... 146
- Color ... 42, 271
- Coloring Matters ... 63, 127, 128
  - Abnormal ... 125
- Concretions ... 189
  - Analysis of ... 192
- Creatinine ... 71
  - Determination of ... 212
- Cystine ... 156
- Cystitis ... 281
- Cysto-Pyelitis ... 279

D

- Diabetes Mellitus ... 239
- Diacetic Acid ... 123
- Diagnosis ... 232
- Donné's Test ... 171

E

- Earthy Phosphates ... 77, 161
- Echinococcus ... 186
- Entozoa ... 186
- Epithelium ... 167

F

- Fat ... 159
- Febrile Urine ... 234
- Fermentation ... 146
- Fibrine ... 87
- Filaria Sanguinis ... 188
- Fungi ... 179

G

PAGE
- Galacturia ... 160
- Globuline ... 94
- Glucose ... 104
- Glycosuria ... 119
- Gonorrhœa ... 299
- Gout ... 239

H

- Hæmatinuria ... 180
- Hæmatoidine ... 295
- Hæmatoporphyrin ... 135
- Hæmaturia ... 275, 277, 278
- Hæmine, Crystals of ... 129
- Hæmoglobinuria ... 268, 275
- Heart, Diseases of ... 237
- Hemi-Albumose ... 96
- Hippuric Acid ... 71
- Hydrobilirubine ... 65
- Hydruria ... 233
- Hyperæmia of Kidney ... 242

I

- Icterus ... 236
- Indican ... 66
  - Jaffe's Test for ... 69
  - Stokvis's Test for ... 69
  - Uroxanthine Test for ... 68
- Indigo ... 66
- Indol ... 69
- Inosite ... 119
- Intermittent Fever ... 240
- Iodine, Determination of ... 145

K

- Kidneys ... 19
  - Histology of ... 19
  - Blood-Vessels of ... 24
  - Nerves of ... 26
  - Excretory Ducts of ... 26
  - Hæmorrhage from ... 275
  - Hyperæmia of ... 242
  - Cirrhosis of ... 252
  - Atrophy of ... 252

PAGE
Kidneys, Abscess of........... 254
  Amyloid.................. 255
Kyesteine.................... 183

L

Lactic Acid.................. 73
Lactose...................... 121
Lactosuria................... 121
Lævulose.................... 120
Leptothrix................... 180
Leucæmia.................... 240
Leucine............... 124, 158
Levulinic Acid............... 124
Liver, Acute Atrophy of....... 236
  Chronic Diseases of......... 240
Lungs, Diseases of............ 237

M

Magnesium Phosphates........ 163
Melanine.................... 131
Meningitis.................. 237
Metallic Salts................ 144
Methæmoglobine......... 128, 272
Microcytes.............. 174, 269
Milk-Sugar.................. 121
Mucin....................... 98
Mucus....................... 165
Murexide Test............... 57

N

Nephritis.................... 245
  Acute Parenchymatous...... 245
  Chronic Parenchymatous.... 249
  Interstitial................ 251
  Suppurative Interstitial...... 253
Nitrogen, Determination of.... 213
Nubecula.................... 146

O

Oïdium Lactis................ 182
Oliguria..................... 234
Oliver's Test Papers.......... 107
Osteomalacia................. 239
Oxalic Acid.................. 72
Oxaluric Acid................ 72

PAGE
Oxybutyric Acid.............. 124
Oxymandelic Acid............ 125

P

Parabanic Acid............... 72
Paraglobuline................ 87
Parasites.................... 179
Parenchymatous Nephritis..... 245
Penicillium Glaucum.......... 182
Pentastoma Denticulatum...... 188
Peptone..................... 95
Peritonitis................... 237
Pettenkofer's Test............ 137
Phosphates.................. 76
  Earthy................ 77, 161
  Triple..................... 164
  Magnesium................ 163
  Calcium................... 163
Phosphoric Acid.............. 221
Picric Acid Tests......... 100, 112
Polyuria..................... 233
Pro-peptone.................. 96
Prostatitis................... 298
Purpura Hæmorrhagica........ 240
Pus-Corpuscles............... 169
Pyelitis...................... 258
  Acute...................... 259
  Chronic.................... 261
Pyelitis Calculosa............. 262
  Tuberculosa................ 264

Q

Qualitative Determination..... 224
  Key to..................... 224
Quantitative Determination.... 200
  Albumen.................. 215
  Chlorine................... 219
  Creatinine................. 212
  Nitrogen.................. 213
  Phosphoric Acid........... 221
  Solids..................... 201
  Sugar..................... 216
  Sulphuric Acid............ 223
  Urea...................... 202
  Uric Acid................. 210

R

PAGE

Rachitis.................... 239
Reaction................ 46, 270
Reagents.................... 197
Rhabdites Genitales........... 188

S

Saccharimeter............... 301
Saccharomyces............... 181
Salicylic Acid................ 145
Sarcinæ..................... 181
Scatol Derivatives............ 135
Scurvy...................... 240
Sediment.................... 146
  Classification of............ 150
Skin-Diseases................ 240
Solids...................... 201
Specific Gravity........... 37, 273
Spectrum.................... 46
Spermatorrhœa............... 298
Spermatozoa............ 183, 299
Spinal Diseases.............. 239
Stokvis's Test (Indican)....... 69
Strongylus Gigas............. 187
Sugar...................... 104
  Böttger's Test for.......... 110
  Heller's Test.............. 105
  Molisch's Test............. 311
  Mulder's Test.............. 107
  Oliver's Test Papers......... 107
  Phenyl-hydrazin Test....... 309
  Picric Acid Test............ 112
  Roberts's Test............. 109
  Trommer's Test............ 107
  Vogel's Test............... 118
  Quantitative Determination.. 216
Sulphates................... 82
Sulphuretted Hydrogen........ 143
Sulphuric Acid............... 83

PAGE

Sulphuric Acid, Determination of 223
Syntonin.................... 194

T

Tyrosine................ 124, 158

U

Urate of Ammonium......... 152
Urates..................... 151
Urea.................... 49, 202
Ureometer.................. 210
Urethra................. 28, 298
Uric Acid.......... 56, 154, 210
Urine...................... 85
  Amount................... 86
  Constituents of............. 85
  Consistence................ 41
  Excretion of............... 30
  Color..................... 42
  Fluorescence............... 45
  Transparency.............. 45
  Reaction.................. 46
  Solids.................... 38
  Specific Gravity............ 37
Urinometer.................. 37
Urobiline................... 64
Urochrome.................. 66
Uroërythrine................ 125
Uroglaucine................. 66
Uro-hæmatine............... 65
Urophæine.................. 65
Uro-rosein.................. 135
Uroxanthine................. 66
Uroxanthine Test............ 68
Urrhodine.................. 66

X

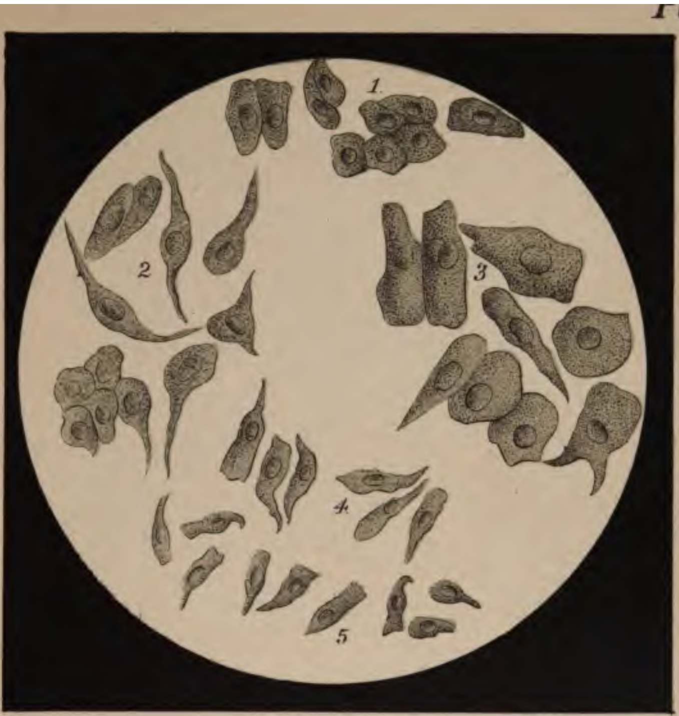
Xanthine.................... 72

Z

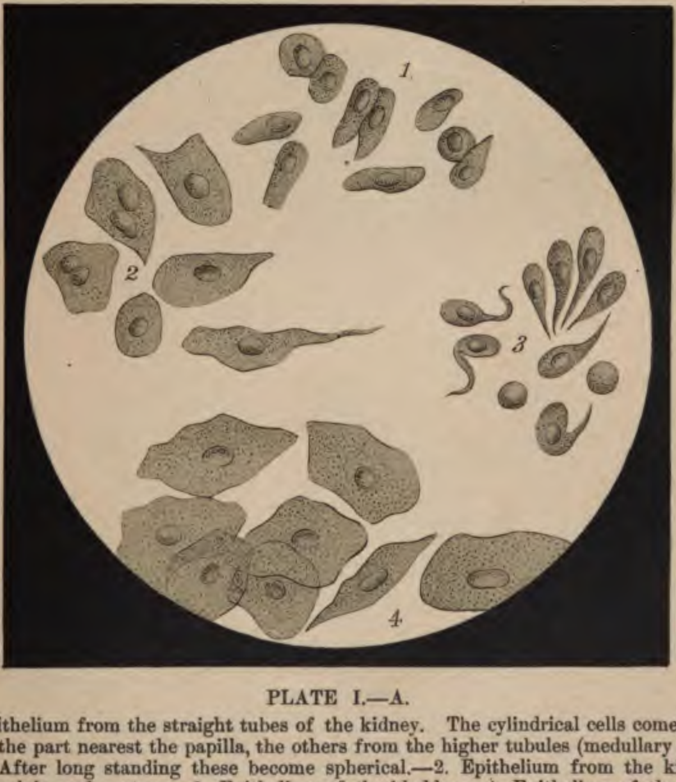
Zoögloa.................... 181

THE END.

Pl. I



A



B

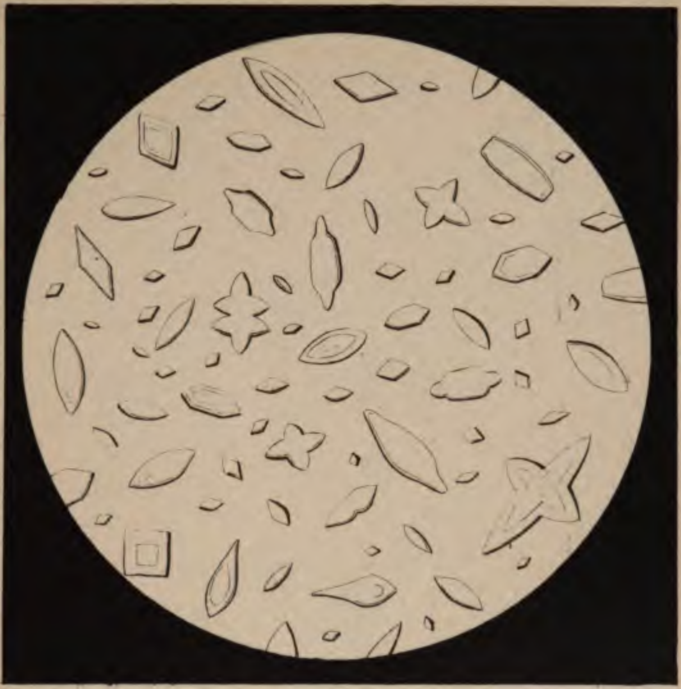
PLATE I.—A.

1. Epithelium from the straight tubes of the kidney. The cylindrical cells come from the part nearest the papilla, the others from the higher tubules (medullary rays). After long standing these become spherical.—2. Epithelium from the kidney, pelvis, and ureters.—3. Epithelium of the bladder.—4. Epithelium of the prostate.—5. Epithelium of Cowper's glands.

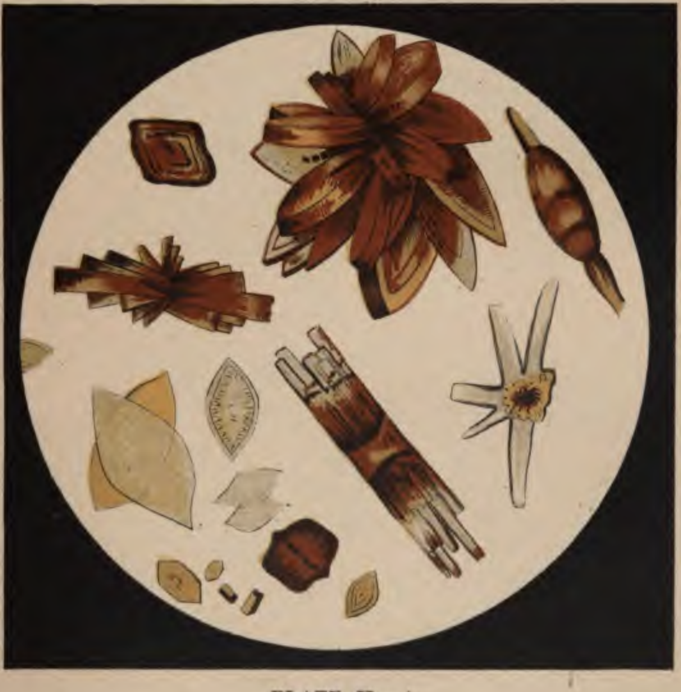
PLATE I.—B.

1. Epithelium of the male urethra.—2. Epithelium of the female urethra.—3. Epithelium of Littré's glands. Plate I., A, 4 and 5, and Plate I., B, 1 and 2, all represent the so-called cylindrical epithelium.—4. Vaginal epithelium.

Pl. II



A



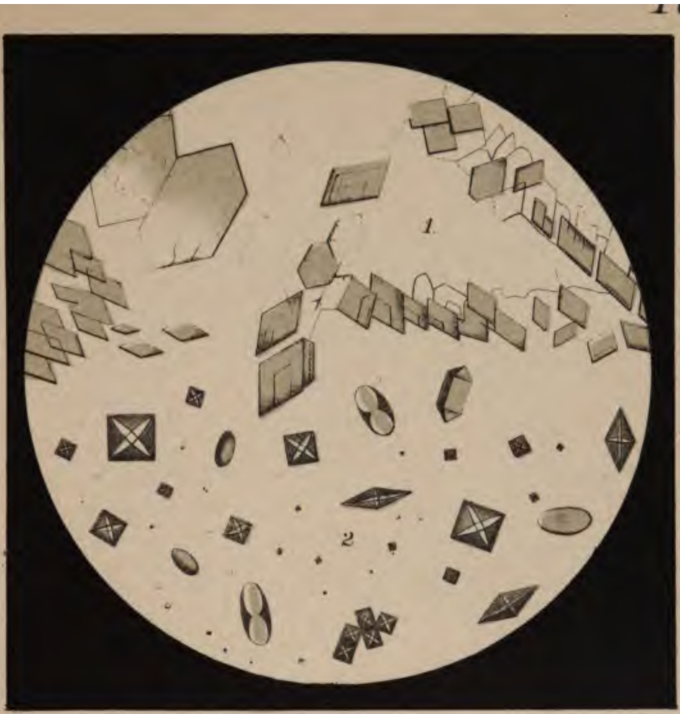
B

PLATE II.—A.

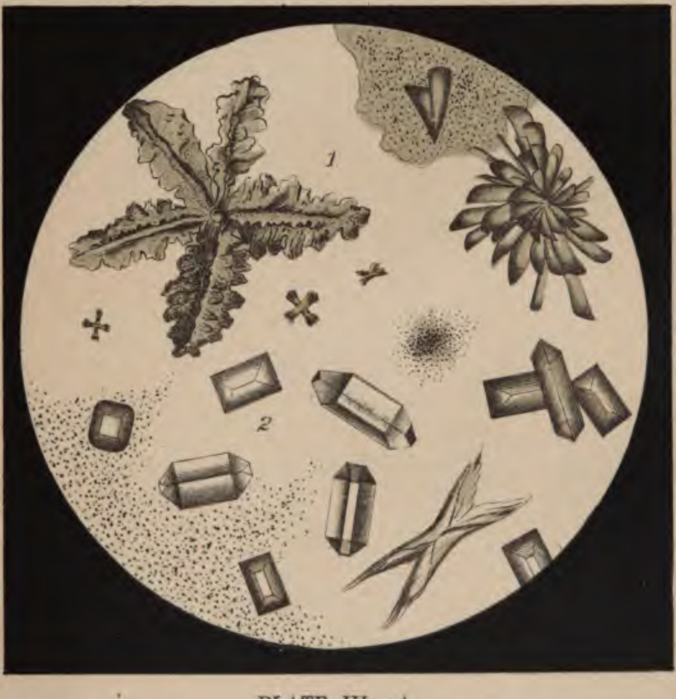
Primary forms of uric-acid crystals, the so-called whetstone crystals. These are always colored as a native precipitate, but are rendered colorless by solution and reprecipitation.

PLATE II.—B.

Uric acid: the sediment as found in native urine; rosettes, and lamellated crystals; also the sharp crystals as found in pyelitis calculosa.



A



B

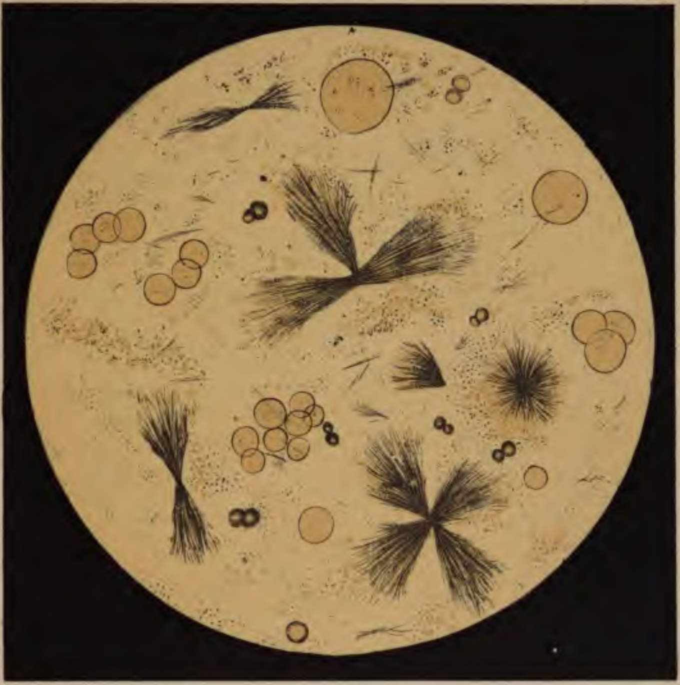
PLATE III.—A.

1. Nitrate of urea, as seen when a drop of HNO_3 is allowed to flow under the cover-glass. Rhombic and hexagonal plates.—2. Oxalate of calcium, as the native sediment of an acid urine. Tetragonal octahedrons and the so-called hour-glass forms.

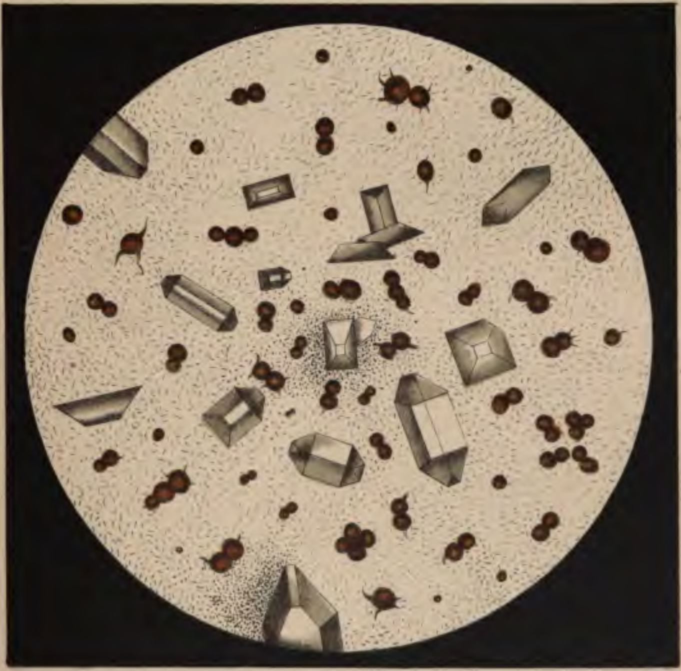
PLATE III.—B.

Triple phosphate $(NH_4)M_gPO_4 + 6H_2O$. The common coffin-lid crystals at the bottom of the figure, and above the fern-leaved crystals of the same, as seen when quickly precipitated by addition of ammonia. The crystals in the upper right-*hand corner* are crystals of phosphate of calcium, of the formula $PO_4HCa +$ *$2H_2O$, from a weakly acid urine, with a tendency to become alkaline. The triple phosphate is found in alkaline urine.*

Pl.IV



A



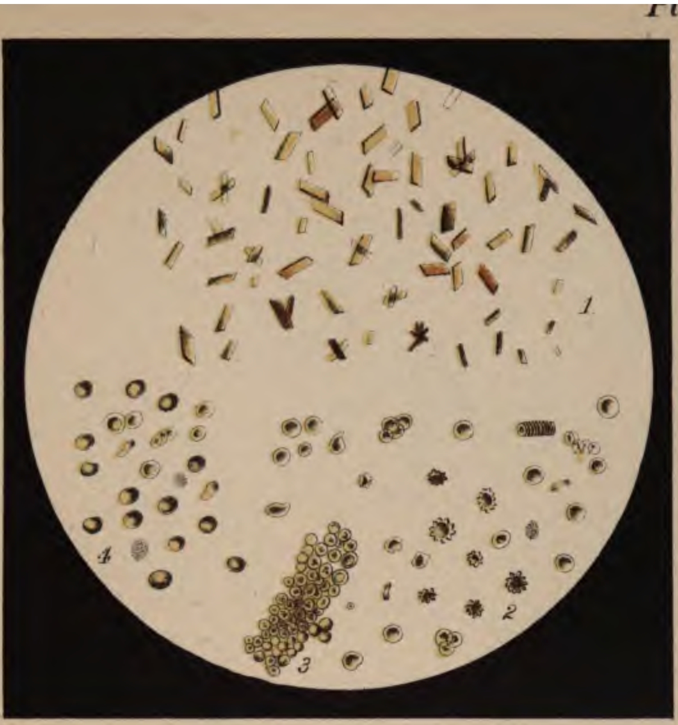
B

PLATE IV.—A.

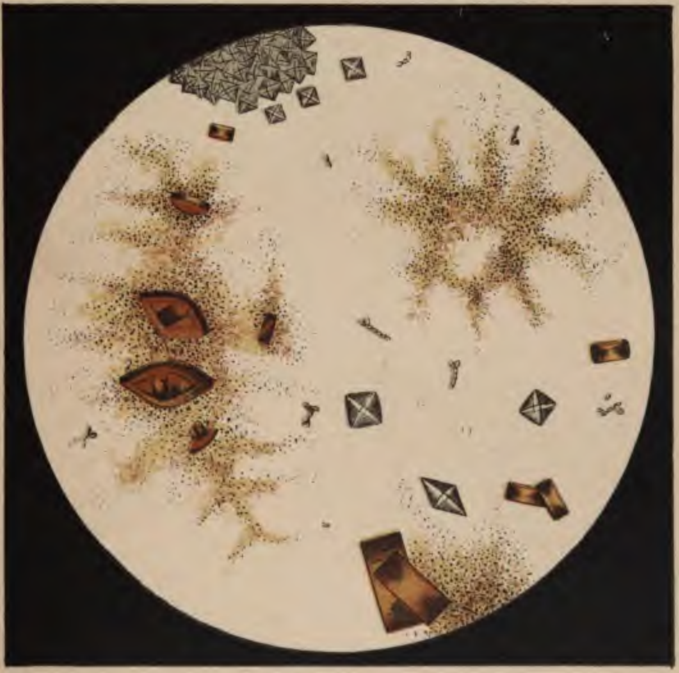
Leucine and tyrosine: sediment from acute yellow atrophy of the liver; sheaves of tyrosine needles, and the drop-like forms of leucine, with small double spheres of ammonium urate.

PLATE IV.—B.

The sediment of alkaline fermentation: the coffin-lid triple phosphates; the brown double spheres of ammonium urate, and the amorphous tribasic calcium phosphates mixed with bacteria.



A



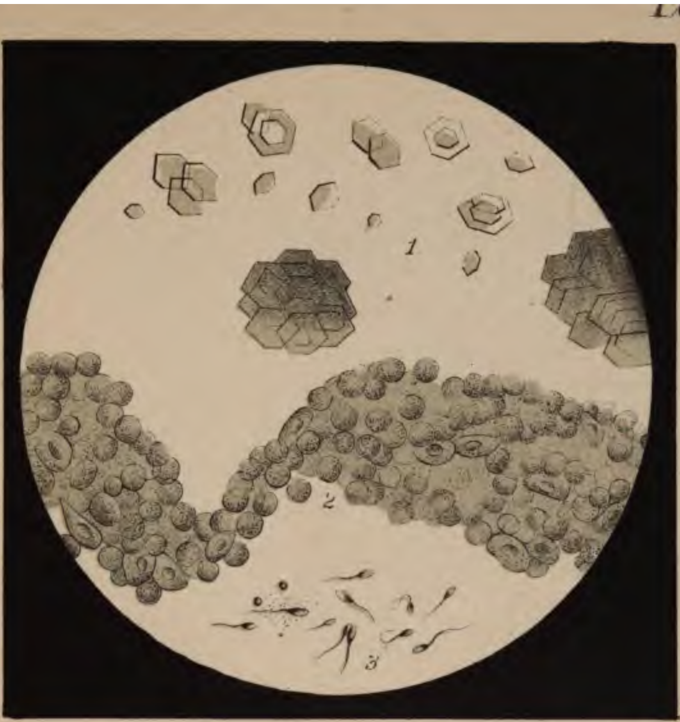
B

PLATE V.—A.

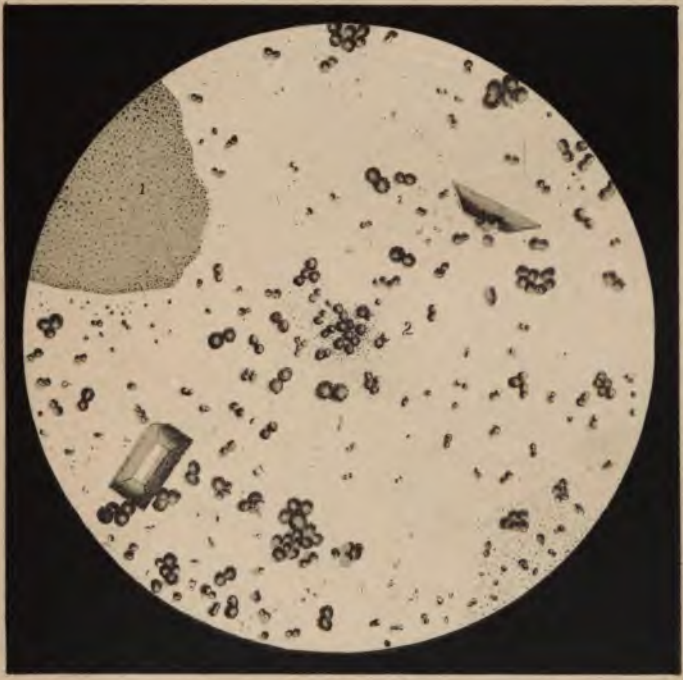
1. Hæmin, or chloride of hæmatin, obtained by adding a grain of salt to the residue of a drop of urine evaporated on an object-glass, and then allowing a drop of acetic acid to flow under the cover.—2. Blood-corpuscles of various forms, and a blood-cylinder.

PLATE V.—B.

Urate of sodium, the amorphous precipitate (sedimentum lateritium); also, the crystals of calcium oxalate and uric acid, together with fermentation fungi, which make up *the sediment* of a febrile urine.



A



B

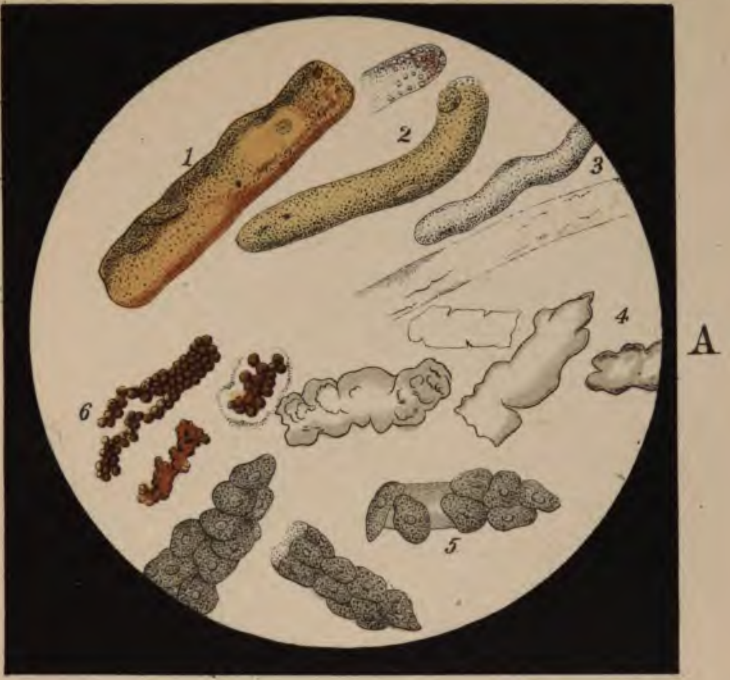
PLATE VI.—A.

1. **Cystine**: the powder of a cystine stone dissolved in ammonia, and evaporated on an object-glass; hexagonal plates, colorless.—2. Gonorrhœal thread, the catarrhal secretion from the accessory glands of the urethra.—3. Spermatozoa.

PLATE VI.—B.

1. **Calcium carbonate**, seldom found.—2. Sediment of an alkaline urine, spheres, dumb-bells, and granular precipitate, found usually in connection with the earthy phosphates.

Pl.VII



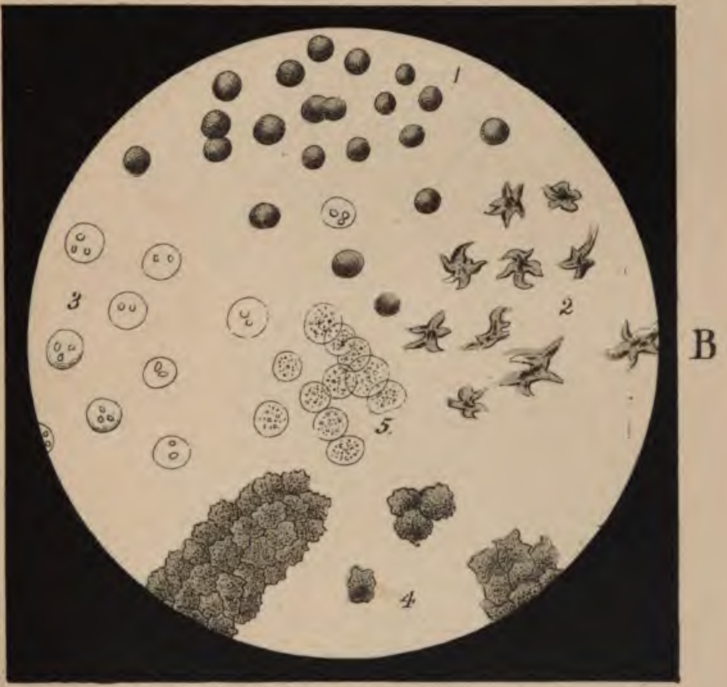


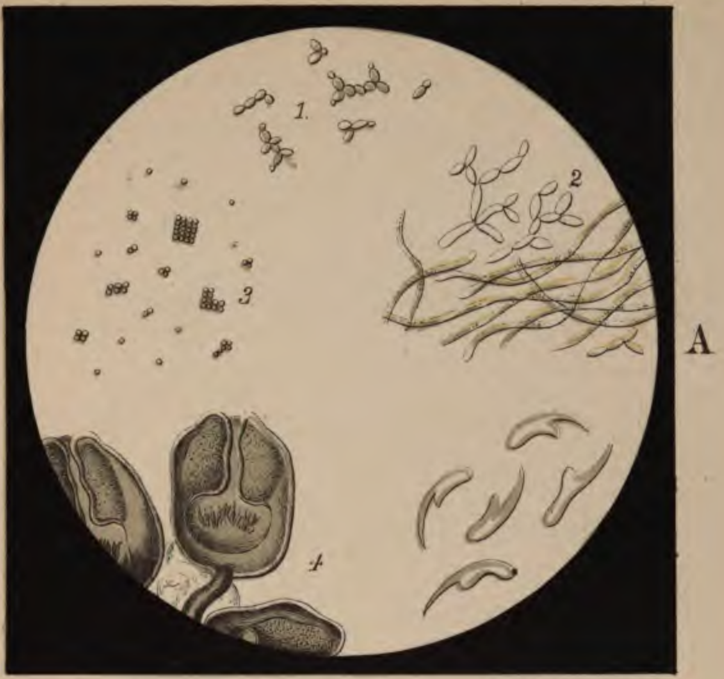
PLATE VII.—A.

1. The massive fibrin cylinder.—2. The granular cylinders.—3. The hyaline cylinder. —4. The waxy cylinders.—5. Epithelial casts and cylinders.—6. The uric-acid cylinders.

PLATE VII.—B.

1. The ordinary pus-corpuscles.—2. Those with prolongations showing amœboid movements.—3. Corpuscles with their nuclei rendered distinct by adding acetic acid.—4. Corpuscles as altered by chronic pyelitis.—5. Corpuscles swollen by *the action of* carbonate of ammonium.

Pl.VIII



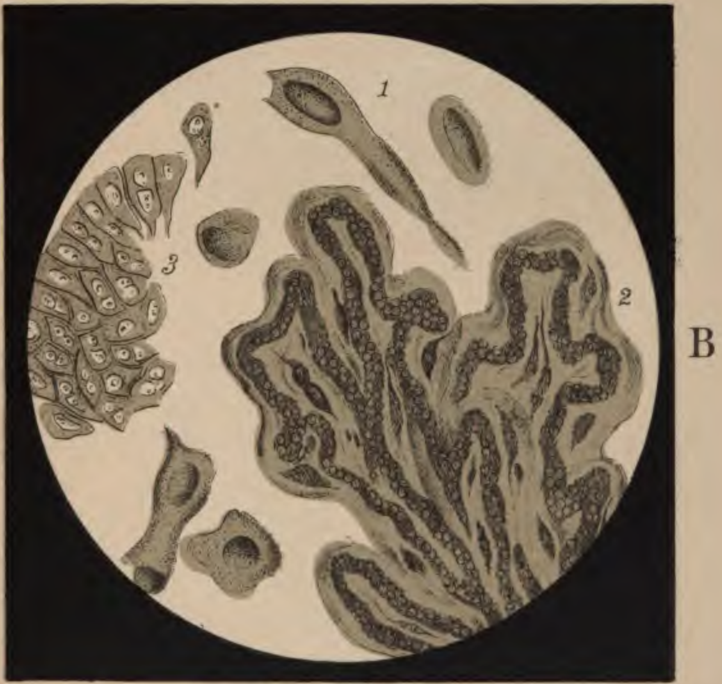


PLATE VIII.—A.

1. Yeast fungi.—2. Penicillum glaucum.—3. Sarcina.—4. Cyst of the echinococcus, with detached hooks.

PLATE VIII.—B.

1. Cancer elements, as seen in the sediment of medullary epithelial cancer of the bladder.—2. A fragment of cancerous villous tissue of seldom occurrence.—3. Epithelial cells stripped from surface of villous cancer.

REASONS WHY PHYSICIANS SHOULD SUBSCRIBE FOR THE

New York Medical Journal,

EDITED BY FRANK P. FOSTER, M. D.,

BECAUSE: It is the *LEADING JOURNAL* of America, and contains more reading-matter than any other journal of its class.

BECAUSE: It is the exponent of the most advanced scientific medical thought.

BECAUSE: Its contributors are among the most learned medical men of this country.

BECAUSE: Its "Original Articles" are the results of scientific observation and research, and are of infinite practical value to the general practitioner.

BECAUSE: The "Reports on the Progress of Medicine," which are published from time to time, contain the most recent discoveries in the various departments of medicine, and are written by practitioners especially qualified for the purpose.

BECAUSE: The column devoted in each number to "Therapeutical Notes" contains a *résumé* of the practical application of the most recent therapeutic novelties.

BECAUSE: The Society Proceedings, of which each number contains one or more, are reports of the practical experience of prominent physicians who thus give to the profession the results of certain modes of treatment in given cases.

BECAUSE: The Editorial Columns are controlled only by the desire to promote the welfare, honor, and advancement of the science of medicine, as viewed from a standpoint looking to the best interests of the profession.

BECAUSE: Nothing is admitted to its columns that has not some bearing on medicine, or is not possessed of some practical value.

BECAUSE: It is published solely in the interests of medicine, and for the upholding of the elevated position occupied by the profession of America.

The volumes begin with January and July of each year. Subscriptions can be arranged to begin with the volume.

Subscription price, $5.00 per Annum.

JOURNAL OF CUTANEOUS AND GENITO-URINARY DISEASES	$2.50	Club rate, $7.00 per annum.
NEW YORK MEDICAL JOURNAL	5.00	

New York: D. APPLETON & CO., 1, 3, & 5 Bond Street.

JOURNAL OF CUTANEOUS AND GENITO-URINARY DISEASES.

Edited by { PRINCE A. MORROW, A. M., M. D., and
JOHN A. FORDYCE, M. D.

PUBLISHED MONTHLY BY D. APPLETON & CO.,

1, 3, & 5 BOND STREET, NEW YORK.

WITH the number for January, 1889, this JOURNAL enters upon the seventh year of its publication. The history of the JOURNAL has been one of progression, and, under the present editorial management, there can be no doubt that it will preserve and increase the reputation already established.

Devoted to the diseases indicated in its title, the JOURNAL will be contributed to by the most eminent dermatologists and syphilographers in this country. Whenever the subject requires illustration, woodcuts or chromo-lithographs will be employed.

Letters from Europe, one or more of which will appear in each issue of the JOURNAL, will keep the reader informed of the advances in this department of medicine at the great medical centers, Vienna, Berlin, and Paris.

A feature of the JOURNAL will be the publication of abstracts of translations of notable papers and selections from foreign journals.

Due prominence will be given to Society Transactions, including papers read and the discussions had thereon, so far as they have a bearing upon the subjects to which the pages of the JOURNAL are devoted.

Both the editors and the publishers will put forth every effort to make the JOURNAL instructive, attractive, and a representative one of its class; and they feel assured that every practitioner, whose work brings him in contact with cutaneous or genito-urinary diseases, will find it of great value and assistance to him.

Subscription price, $2.50 per annum.

NEW YORK MEDICAL JOURNAL - - - - -	$5.00	Club rate, $7.00 per annum.
JOURNAL OF CUTANEOUS AND GENITO-URINARY DISEASES - - - - - - - - -	$2.50	

Established by EDWARD L. YOUMANS.

THE POPULAR SCIENCE MONTHLY,

Edited by W. J. YOUMANS,

Well known as a trustworthy medium for the spread of scientific truth in popular form, is filled with articles of interest to everybody, by the ablest writers of the time. Its range of topics, which is widening with the advance of science, includes—

- *SOCIAL AND DOMESTIC ECONOMY.*
- *POLITICAL SCIENCE, OR THE CONDUCT OF GOVERNMENT.*
- *SCIENTIFIC ETHICS; MENTAL SCIENCE AND EDUCATION.*
- *MAN'S ORIGIN AND DEVELOPMENT.*
- *RELATIONS OF SCIENCE AND RELIGION.*
- *PREVENTION OF DISEASE, AND IMPROVEMENT OF THE RACE.*
- *AGRICULTURE AND FOOD PRODUCTS.*
- *THE INDUSTRIAL ARTS.*
- *NATURAL HISTORY; DISCOVERY; EXPLORATION, ETC.*

With other illustrations, each number contains a finely-engraved **Portrait** of some eminent scientist, with a **Biographical Sketch.**

Among its recent contributors are: Herbert Spencer, Andrew D. White, David A. Wells, T. H. Huxley, Sir John Lubbock, Edward Atkinson, W. K. Brooks, Grant Allen, E. D. Cope, Thomas Hill, David Starr Jordan, Joseph Le Conte, Appleton Morgan, Felix L. Oswald, Sir William Dawson, F. W. Clarke, Horatio Hale, Edward S. Morse, J. S. Newberry, Eugene L. Richards, N. S. Shaler, D. G. Thompson.

WHAT IS SAID OF THE MONTHLY.

"'The Popular Science Monthly' has long since taken its place as the one magazine which deals with science in a popular manner. In this respect it certainly has no rival and no peer. That it is not too solid for a large and growing body of readers its prosperity demonstrates."—*New York Tribune.*

"'The Popular Science Monthly' is devoted to nothing except Truth as far as it has yet been discovered—Truth at all hazards, and irrespective of consequences. . . . To thoughtfully read 'The Popular Science Monthly' is to have mastered at least the rudiments of the largest education that has yet been attained on earth."—*New York Mail and Express.*

"This magazine has made a field for itself, in which it stands alone. It has done more to popularize science than all other publications added together, and well deserves the marked success which it has attained."—*The Republic* (Washington).

"There is no diminution in the excellence of this magazine since Prof. Youmans's death. It is well established, and has the highest fame for a work of its kind."—*Boston Herald.*

"The magazine is as trenchant, progressive, thoroughly informed, and full of ability as it ever was." —*Utica* (N. Y.) *Herald.*

"'The Popular Science Monthly' can not be excelled."—*Hartford* (Conn.) *Evening Post.*

New York: D. APPLETON & COMPANY, 1, 3, & 5 Bond Street.

Single Number, 50 cents. **Yearly Subscription, $5.00.**

LECTURES UPON DISEASES OF THE RECTUM AND THE SURGERY OF THE LOWER BOWEL.

Delivered at the Bellevue Hospital Medical College by W. H. VAN BUREN, M. D., late Professor of the Principles and Practice of Surgery in the Bellevue Hospital Medical College, etc., etc.

Second edition, revised and enlarged. One volume, 8vo, 412 pages, with 27 Illustrations and complete Index. Cloth, $3.00; sheep, $4.00.

"The reviewer too often finds it a difficult task to discover points to praise, in order that his criticisms may not seem one-sided and unjust. These lectures, however, place him upon the other horn of the dilemma, viz., to find somewhat to criticise severely enough to clear himself of the charge of indiscriminating laudation. Of course, the author upholds some views which conflict with other authorities, but he substantiates them by the most powerful of arguments, viz., a large experience, the results of which are enunciated by one who elsewhere shows that he can appreciate, and accord the due value to, the work and experience of others."—*Archives of Medicine.*

"The present is a new volume rather than a new edition. Both its size and material are vastly beyond its predecessor. The same scholarly method, the same calm, convincing statement, the same wise, carefully matured counsel, pervade every paragraph. The discomfort and dangers of the diseases of the rectum call for greater consideration than they usually receive at the hands of the profession."—*Detroit Lancet.*

A PRACTICAL TREATISE ON THE SURGICAL DISEASES OF THE GENITO-URINARY ORGANS, INCLUDING SYPHILIS.

Designed as a Manual for Students and Practitioners. With Engravings and Cases. By W. H. VAN BUREN, A. M., M. D., late Professor of Principles of Surgery, with Diseases of the Genito-Urinary System and Clinical Surgery, in Bellevue Hospital Medical College, etc., and E. L. KEYES, A. M., M. D., Professor of Dermatology in Bellevue Hospital Medical College; Surgeon to the Charity Hospital, Venereal Diseases, etc.

One volume, 8vo, 672 pages. Cloth, $5.00; sheep, $6.00.

This work is really a compendium of, and a book of reference to, all modern works treating in any way of the surgical diseases of the genito-urinary organs. At the same time, no other single book contains so large an array of *original* facts concerning the class of diseases with which it deals. These facts are largely drawn from the extensive and varied experience of the authors.

Many important branches of genito-urinary diseases, as the cutaneous maladies of the penis and scrotum, receive a thorough and exhaustive treatment that the professional reader will search for elsewhere in vain.

The subject of syphilis is included, of necessity, in this treatise. Although properly belonging to the department of Principles of Surgery, there is no disease falling within the limits of this work concerning which clear and correct ideas as to nature and treatment will, at the present time, so seriously influence success in practice.

The work is elegantly and profusely illustrated, and enriched by fifty-five original cases, setting forth obscure and difficult points in diagnosis and treatment.

New York: D. APPLETON & CO., 1, 3, & 5 Bond Street.

A MANUAL OF OPERATIVE SURGERY.

By JOSEPH D. BRYANT, M. D.,

Professor of Anatomy and Clinical Surgery, and Associate Professor of Orthopædic Surgery in Bellevue Hospital Medical College; Visiting Surgeon to Bellevue and St. Vincent's Hospitals, and Consulting Surgeon to the New York Lunatic Asylum, etc.

NEW EDITION, REVISED AND ENLARGED.

8vo, 530 pages and 793 Illustrations. ***Cloth, $5.00; sheep, $6.00.***

We invite the attention of students and practitioners of medicine to the following opinions and notices of this sterling work:

Dr. J. Williston Wright, *Professor of Surgery in the Medical Department of the University of the City of New York, and in the Medical Department of the University of Vermont, writes:*

"The concise and systematic manner in which the accomplished author has treated the subject meets my hearty approval; and as a book, fully up to the times in whatever the crucial test of experience has assigned a *definite* place in our art, should commend itself alike to students and practitioners of medicine and surgery."

Dr. Roswell Park, *Professor of the Principles and Practice of Surgery and Clinical Surgery in the Medical Department of the University of Buffalo, writes:*

". . . It is, according to my notion, the best work of its kind now before the public, and I shall take great pleasure, not only in commending it to others, but in making it my own guide. . . ."

Dr. C. T. Parkes, *Professor of Surgery in Rush Medical College, Chicago, writes:*

"It gives me great pleasure to express my opinion of the excellence of Dr. Bryant's 'Manual of Operative Surgery.' For clearness of description, precision of statement, order in the arrangement of subjects, and faithfulness in illustration, the work surpasses anything of the kind in my possession."

". . . We know of no better work on operative surgery to place in the hands of the student or of the young surgeon. . . ."—*Medical Record.*

". . . We can recommend this book with confidence, both to advanced students and practicing surgeons; we have seen nothing of the kind we like so well."—*Canadian Practitioner.*

"This work by Dr. Bryant, one of the foremost surgeons of New York, is a credit to our country and profession. The book is of a handy size, and printed from good, clear type, and yet, with these advantages, it has not been condensed so as to deprive it of the value of the most complete work on operative surgery. In addition to the author's clear and forcible style, we find everything splendidly illustrated that could in any sense of the word require illustrating."—*Southern Clinic.*

"It is the character of book that every surgeon needs for ready reference, since it is not always that one has time to refer to more comprehensive works, or to atlases. It is especially useful for physicians in the country, who have not the amount of surgical practice required to keep them familiar with the entire field of operation."—*American Practitioner and News.*

"The author of this work seems to know how, in the briefest space, to give the student of surgery the aid necessary 'to acquire established facts,' and this is an important point in a book of this kind. The text is most fully illustrated, and brings the subject to date."—*New York Medical Times.*

New York: D. APPLETON & CO., 1, 3, & 5 Bond Street.

A TEXT-BOOK ON SURGERY:

GENERAL, OPERATIVE, AND MECHANICAL.

By **JOHN A. WYETH, M. D.,**

Professor of Surgery in the New York Polyclinic; Surgeon to Mount Sinai Hospital, etc.

Price, Buckram, uncut edges, $7.00; Sheep, $8.00; Half Morocco, $8.50.

SOLD BY SUBSCRIPTION ONLY.

This work, consisting of seven hundred and sixty-nine pages, and containing seven hundred and seventy-one illustrations, of which about fifty are colored, is one of the most beautiful and unique, and at the same time one of the most complete, works on general surgery ever published.

It is printed in clear, large type on a superior quality of paper, and the book, large without being bulky, is in a shape to be easily handled. The illustrations are executed with especial reference to the accurate anatomy of the parts represented; the relations of bones, muscles, nerves, and vessels to adjacent structures; and lines of incision are indicated in operations about the joints and articulations, thus explaining and simplifying their descriptions in the text. The colored illustrations which depict the more important operations, especially with reference to the large arteries, constitute a novel and very important feature of the work.

The following brief synopsis will convey an idea of the plan of the work:

As a preliminary to the consideration of the various operations the author thoroughly discusses the methods of preparing the different antiseptic surgical dressings, ligatures, sutures, solutions, drains; the materials for bandaging, with illustrated instructions as to the manner of applying bandages in the various forms employed in different parts of the body; anæsthesia, both local and general, including the employment of cocaine as a local anæsthetic; the use and method of administering ether and chloroform; instruments and their uses; hæmostasis and the after-treatment of cases.

Inflammation, its causes and methods of treatment; wounds and the manner of closing them; transfusion, poisoned wounds, burns and scalds, gangrene, and the various surgical lesions are thoroughly considered and their appropriate treatment given.

Amputations, with full and minute details of the manner of performing them, and the different methods employed, constitute an important chapter in the book. All the principal operations are illustrated by colored engravings made from direct tracings of frozen sections on the cadaver.

The section devoted to the arteries and the procedures necessary in ligating them is one of the most important and most beautifully illustrated portions of the work. The woodcuts showing the relation of the parts involved in tying the important arteries are colored, and their anatomy is depicted in a wonderfully clear and accurate manner.

Surgical diseases and surgery of the bones; surgery of the articulations, regional surgery, including the common operations on the eye, ear, and jaws; tumors about the neck, thyreotomy, laryngotomy, tracheotomy, and œsophagotomy; the surgery of the thorax and abdomen; and operations on the rectum and anus are dealt with in the light of the most advanced surgical knowledge.

Genito-urinary surgery and specific lesions receive a due share of attention, as do deformities of the spine and extremities, and malignant tumors and growths.

This work, written by an accomplished surgeon of wide experience, and fully abreast of the highest attainments in surgical knowledge and science, presents to the student and practitioner a means of acquainting himself with modern surgery as it is taught and practiced by a master of the art, and will enable him to prepare himself for the intelligent performance of many operations, and to treat many surgical lesions with which he may feel he is not sufficiently familiar.

D. APPLETON & CO., Publishers,
1, 3, & 5 BOND ST., NEW YORK.

March, 1889.

MEDICAL

AND

HYGIENIC WORKS

PUBLISHED BY

D. APPLETON & CO., 1, 3, & 5 Bond Street, New York.

BARKER (FORDYCE). On Sea-Sickness. A Popular Treatise for Travelers and the General Reader. Small 12mo. Cloth, 75 cents.

BARKER (FORDYCE). On Puerperal Disease. Clinical Lectures delivered at Bellevue Hospital. A Course of Lectures valuable alike to the Student and the Practitioner. Third edition. 8vo. Cloth, $5.00; sheep, $6.00.

BARTHOLOW (ROBERTS). A Treatise on Materia Medica and Therapeutics. **Sixth edition.** Revised, enlarged, and adapted to "The New Pharmacopœia." 8vo. Cloth, $5.00; sheep, $6.00.

BARTHOLOW (ROBERTS). A Treatise on the Practice of Medicine, for the Use of Students and Practitioners. **Sixth edition,** revised and enlarged. 8vo Cloth, $5.00; sheep, $6.00.

BARTHOLOW (ROBERTS). On the Antagonism between Medicines and between Remedies and Diseases. Being the Cartwright Lectures for the Year 1880. 8vo. Cloth, $1.25.

BASTIAN (H. CHARLTON). Paralysis: Cerebral, Bulbar, and Spinal. Illustrated. Small 8vo. Cloth, $4.50.

BASTIAN (H. CHARLTON). The Brain as an Organ of the Mind. 12mo. Cloth, $2.50.

BELLEVUE AND CHARITY HOSPITAL REPORTS. Edited by W. A. Hammond, M. D. 8vo. Cloth, $4.00.

BENNET (J. H.). On the Treatment of Pulmonary Consumption, by Hygiene, Climate, and Medicine. Thin 8vo. Cloth, $1.50.

BILLINGS (F. S.). The Relation of Animal Diseases to the Public Health, and their Prevention. 8vo. Cloth, $4.00.

BILLROTH (THEODOR). General Surgical Pathology and Therapeutics. A Text-Book for Students and Physicians. Translated from the tenth German edition, by special permission of the author, by Charles E. Hackley, M. D. **Fifth American edition, revised and enlarged.** 8vo. Cloth, $5.00; sheep, $6.00.

BRAMWELL (BYROM). Diseases of the Heart and Thoracic Aorta. Illustrated with 226 Wood-Engravings and 68 Lithograph Plates—showing 91 Figures—in all 317 Illustrations. 8vo. Cloth, $8.00; sheep, $9.00.

BRYANT (JOSEPH D.). A Manual of Operative Surgery. **New edition, revised and enlarged.** 793 Illustrations. 8vo. Cloth, $5.00; sheep, $6.00.

BUCK (GURDON). Contributions to Reparative Surgery, showing its Application to the Treatment of Deformities produced by Destructive Disease or Injury; Congenital Defects from Arrest or Excess of Development; and Cicatricial Contractions following Burns. Illustrated by Thirty Cases and fine Engravings. 8vo. Cloth, $3.00.

BURT (STEPHEN SMITH). Exploration of the Chest in Health and Disease. (*In press.*)

CAMPBELL (F. R.). The Language of Medicine. A Manual giving the Origin, Etymology, Pronunciation, and Meaning of the Technical Terms found in Medical Literature. 8vo. Cloth, $3.00.

CARPENTER (W. B.). Principles of Mental Physiology, with their Application to the Training and Discipline of the Mind, and the Study of its Morbid Conditions. 12mo. Cloth, $3.00.

CARTER (ALFRED H.). Elements of Practical Medicine. **Third edition,** revised and enlarged. 12mo. Cloth, $3.00.

CASTRO (D'OLIVEIRA). Elements of Therapeutics and Practice according to the Dosimetric System. 8vo. Cloth, $4.00.

COOLEY. Cyclopædia of Practical Receipts, and Collateral Information in the Arts, Manufactures, Professions, and Trades, including Medicine, Pharmacy, and Domestic Economy. Designed as a Comprehensive Supplement to the Pharmacopœia, and General Book of Reference for the Manufacturer, Tradesman, Amateur, and Heads of Families. **Sixth edition,** revised and partly rewritten by Richard V. Tuson. With Illustrations. 2 vols., 8vo. Cloth, $9.00.

CORNING (J. L.). Brain Exhaustion, with some Preliminary Considerations on Cerebral Dynamics. Crown 8vo. Cloth, $2.00.

CORNING (J. L.). Local Anæsthesia in General Medicine and Surgery. Being the Practical Application of the Author's Recent Discoveries. With Illustrations. Small 8vo. Cloth, $1.25.

ELLIOT (GEORGE T.). Obstetric Clinic: A Practical Contribution to the Study of Obstetrics and the Diseases of Women and Children. 8vo. Cloth, $4.50.

EVANS (GEORGE A.). Hand-Book of Historical and Geographical Phthisiology. With Special Reference to the Distribution of Consumption in the United States. 8vo. Cloth, $2.00.

EVETZKY (ETIENNE). The Physiological and Therapeutical Action of Ergot. Being the Joseph Mather Smith Prize Essay for 1881. 8vo. Limp cloth, $1.00.

FLINT (AUSTIN). Medical Ethics and Etiquette. Commentaries on the National Code of Ethics. 12mo. Cloth, 60 cents.

FLINT (AUSTIN). Medicine of the Future. An Address prepared for the Annual Meeting of the British Medical Association in 1886. With Portrait of Dr. Flint. 12mo. Cloth, $1.00.

FLINT (AUSTIN, JR.). Text-Book of Human Physiology; designed for the Use of Practitioners and Students of Medicine. Illustrated with three hundred and sixteen Woodcuts and Two Plates. **Fourth edition, revised.** Imperial 8vo. Cloth, $6.00; sheep, $7.00.

FLINT (AUSTIN JR.). The Physiological Effects of Severe and Protracted Muscular Exercise; with Special Reference to its Influence upon the Excretion of Nitrogen. 12mo. Cloth, $1.00.

FLINT (AUSTIN, Jr.). Physiology of Man. Designed to represent the Existing State of Physiological Science as applied to the Functions of the Human Body. Complete in 5 vols., 8vo. Per vol., cloth, $4.50; sheep, $5.50.

⁂ Vols. I and II can be had in cloth and sheep binding; Vol. III in sheep only. Vol. IV is at present out of print.

FLINT (AUSTIN, Jr.). The Source of Muscular Power. Arguments and Conclusions drawn from Observation upon the Human Subject under Conditions of Rest and of Muscular Exercise. 12mo. Cloth, $1.00.

FLINT (AUSTIN, Jr.). Manual of Chemical Examinations of the Urine in Disease; with Brief Directions for the Examination of the most Common Varieties of Urinary Calculi. Revised edition. 12mo. Cloth, $1.00.

FOSTER (FRANK P.). Illustrated Encyclopædic Medical Dictionary, being a Dictionary of the Technical Terms used by Writers on Medicine and the Collateral Sciences in the Latin, English, French, and German Languages. This work will be completed in four volumes. (*Sold by subscription only.*) Volume one now ready. 8vo. Sheep, $10.00; half morocco, $11.00.

FOTHERGILL (J. MILNER). Diseases of Sedentary and Advanced Life. 8vo. Cloth, $2.00.

FOURNIER (ALFRED). Syphilis and Marriage. Translated by P. Albert Morrow, M. D. 8vo. Cloth, $2.00; sheep, $3.00.

FREY (HEINRICH). The Histology and Histochemistry of Man. A Treatise on the Elements of Composition and Structure of the Human Body. Translated from the fourth German edition by Arthur E. J. Barker, M. D., and revised by the author. With 608 Engravings on Wood. 8vo. Cloth, $5.00; sheep, $6.00.

FRIEDLANDER (CARL). The Use of the Microscope in Clinical and Pathological Examinations. Second edition, enlarged and improved, with a Chromo-lithograph Plate. Translated, with the permission of the author, by Henry C. Coe, M. D. 8vo. Cloth, $1.00.

GARMANY (JASPER J.). Operative Surgery on the Cadaver. With Two Colored Diagrams showing the Collateral Circulation after Ligatures of Arteries of Arm, Abdomen, and Lower Extremity. Small 8vo. Cloth, $2.00.

GERSTER (ARPAD G.). The Rules of Aseptic and Antiseptic Surgery. A Practical Treatise for the Use of Students and the General Practitioner. Illustrated with over two hundred fine Engravings. 8vo. Cloth, $5.00; sheep, $6.00.

GROSS (SAMUEL W.). A Practical Treatise on Tumors of the Mammary Gland. Illustrated. 8vo. Cloth, $2.50.

GUTMANN (EDWARD). The Watering-Places and Mineral Springs of Germany, Austria, and Switzerland. Illustrated. 12mo. Cloth, $2.50.

GYNÆCOLOGICAL TRANSACTIONS. 8vo. Cloth, per volume, $5.00.

Vol. VIII. Being the Proceedings of the Eighth Annual Meeting of the American Gynæcological Society, held in Philadelphia, September 18, 19, and 20, 1883.

Vol. IX. Being the Proceedings of the Ninth Annual Meeting of the American Gynæcological Society, held in Chicago, September 30, and October 1 and 2, 1884.

Vol. X. Being the Proceedings of the Tenth Annual Meeting of the American Gynæcological Society, held in Washington, D. C., September 22, 23, and 24, 1885.

GYNÆCOLOGICAL TRANSACTIONS. 8vo. Cloth, per volume, $5.00.

Vol. XI. Being the Proceedings of the Eleventh Annual Meeting of the American Gynæcological Society, held in Baltimore, Maryland, September, 21, 22, and 23, 1886

Vol. XII. Being the Proceedings of the Twelfth Annual Meeting of the American Gynæcological Society, held in New York, Tuesday, Wednesday, and Thursday, September 13, 14, and 15, 1887.

HAMMOND (W. A.). A Treatise on Diseases of the Nervous System. **Eighth edition,** rewritten, enlarged, and improved. 8vo. Cloth, $5.00; sheep, $6.00.

HAMMOND (W. A.). A Treatise on Insanity, in its Medical Relations. 8vo. Cloth, $5.00; sheep, $6.00.

HAMMOND (W. A.). Clinical Lectures on Diseases of the Nervous System. Delivered at Bellevue Hospital Medical College. Edited by T. M. B. Cross, M. D. 8vo. Cloth, $3.50.

HARVEY (A.). First Lines of Therapeutics. 12mo. Cloth, $1.50.

HOFFMANN-ULTZMANN. Analysis of the Urine, with Special Reference to Diseases of the Urinary Apparatus. By M. B. Hoffmann, Professor in the University of Gratz; and R. Ultzmann, Tutor in the University of Vienna. **Second enlarged and improved edition.** 8vo. Cloth, $2.00.

HOWE (JOSEPH W.). Emergencies, and how to treat them. Fourth edition, revised. 8vo. Cloth, $2.50.

HOWE (JOSEPH W.). The Breath, and the Diseases which give it a Fetid Odor. With Directions for Treatment. **Second edition,** revised and corrected. 12mo. Cloth, $1.00.

HUEPPE (FERDINAND). The Methods of Bacteriological Investigation. Written at the request of Dr. Robert Koch. Translated by Hermann M. Biggs, M. D. Illustrated. 8vo. Cloth, $2.50.

JACCOUD (S.). The Curability and Treatment of Pulmonary Phthisis. Translated and edited by Montagu Lubbock, M. D. 8vo. Cloth, $4.00.

JONES (H. MACNAUGHTON). Practical Manual of Diseases of Women and Uterine Therapeutics. For Students and Practitioners. 188 Illustrations. 12mo. Cloth, $3.00.

JOURNAL OF CUTANEOUS AND GENITO-URINARY DISEASES. Published Monthly. Edited by Prince A. Morrow, A. M., M. D., and John A. Fordyce, M. D. Price, $2.50 per annum, or, if taken in connection with the "New York Medical Journal" ($5.00 per annum), the two publications will be furnished at $7.00 per annum.

KEYES (E. L.). A Practical Treatise on Genito-Urinary Diseases, including Syphilis. Being a new edition of a work with the same title, by Van Buren and Keyes. Almost entirely rewritten. 8vo. With Illustrations. Cloth, $5.00; sheep, $6.00.

KEYES (E. L.). The Tonic Treatment of Syphilis, including Local Treatment of Lesions. 8vo. Cloth, $1.00.

KINGSLEY (N. W.). A Treatise on Oral Deformities as a Branch of Mechanical Surgery. With over 350 Illustrations. 8vo. Cloth, $5.00; sheep, $6.00.

LEGG (J. WICKHAM). On the Bile, Jaundice, and Bilious Diseases. With Illustrations in Chromo-Lithography. 8vo. Cloth, $6.00; sheep, $7.00.

LITTLE (W. J.). Medical and Surgical Aspects of In-Knee (Genu-Valgum): its Relation to Rickets, its Prevention, and its Treatment, with and without Surgical Operation. Illustrated by upward of Fifty Figures and Diagrams. 8vo. Cloth, $2.00.

LORING (EDWARD G.). A Text-Book of Ophthalmoscopy. Part I. The Normal Eye, Determination of Refraction, and Diseases of the Media. With 131 Illustrations, and 4 Chromo-Lithographs. 8vo. Cloth, $5.00.

LUSK (WILLIAM T.). The Science and Art of Midwifery. With 246 Illustrations. **Second edition, revised and enlarged.** 8vo. Cloth, $5.00; sheep, $6.00.

LUYS (J.). The Brain and its Functions. With Illustrations. 12mo. Cloth, $1.50.

MARKOE (T. M.). A Treatise on Diseases of the Bones. With Illustrations. 8vo. Cloth, $4.50.

MAUDSLEY (HENRY). Body and Mind: an Inquiry into their Connection and Mutual Influence, specially in reference to Mental Disorders. An enlarged and revised edition, to which are added Psychological Essays. 12mo. Cloth, $1.50.

MAUDSLEY (HENRY). Physiology of the Mind. Being the first part of a third edition, revised, enlarged, and in great part rewritten, of "The Physiology and Pathology of the Mind." 12mo. Cloth, $2.00.

MAUDSLEY (HENRY). Pathology of the Mind. Third edition. 12mo. Cloth, $2.00.

MAUDSLEY (HENRY). Responsibility in Mental Disease. 12mo. Cloth, $1.50.

NEFTEL (WM. B.). Galvano-Therapeutics. The Physiological and Therapeutical Action of the Galvanic Current upon the Acoustic, Optic, Sympathetic, and Pneumogastric Nerves. 12mo. Cloth, $1.50.

NEUMANN (ISIDOR). Hand-Book of Skin Diseases. Translated by Lucius D. Bulkley, M. D. Illustrated by 66 Wood-Engravings. 8vo. Cloth, $4.00; sheep, $5.00.

THE NEW YORK MEDICAL JOURNAL (weekly). Edited by Frank P. Foster, M. D. Terms per annum, $5.00, or, if taken in connection with the Journal of Cutaneous and Genito-Urinary Diseases ($2.50 per annum), the two publications will be supplied at $7.00 per annum.

Binding Cases, cloth, 50 cents each.

GENERAL INDEX, from April, 1865, to June, 1876 (23 vols.) 8vo. Cloth, 75 cents.

THE NEW YORK MEDICAL JOURNAL VISITING-LIST AND COMPLETE POCKET ACCOUNT-BOOK. Prepared by Charles H. Shears, M. D. $1.25.

NIEMEYER (FELIX VON). A Text-Book of Practical Medicine, with particular reference to Physiology and Pathological Anatomy. Containing all the author's Additions and Revisions in the eighth and last German edition. Translated by George H. Humphreys, M. D., and Charles E. Hackley, M. D. 2 vols., 8vo. Cloth, $9.00; sheep, $11.00.

NIGHTINGALE'S (FLORENCE) Notes on Nursing. 12mo. Cloth, 75 cents.

PEASLEE (E. R.). A Treatise on Ovarian Tumors: their Pathology, Diagnosis, and Treatment, with reference especially to Ovariotomy. With Illustrations. 8vo. Cloth, $5.00; sheep, $6.00.

PEREIRA'S (Dr.) Elements of Materia Medica and Therapeutics. Abridged and adapted for the Use of Medical and Pharmaceutical Practitioners and Students, and comprising all the Medicines of the British Pharmacopœia, with such others as are frequently ordered in Prescriptions, or required by the Physician. Edited by Robert Bentley and Theophilus Redwood. Royal 8vo. Cloth, $7.00; sheep, $8.00.

PEYER (ALEXANDER). An Atlas of Clinical Microscopy. Translated and edited by Alfred C. Girard, M. D. First American, from the manuscript of the second German edition, with Additions. Ninety Plates, with 105 Illustrations, Chromo-Lithographs. Square 8vo. Cloth, $6.00.

POMEROY (OREN D.). The Diagnosis and Treatment of Diseases of the Ear. With One Hundred Illustrations. **Second edition,** revised and enlarged. 8vo. Cloth, $3.00.

POORE (C. T.). Osteotomy and Osteoclasis, for the Correction of Deformities of the Lower Limbs. 50 Illustrations. 8vo. Cloth, $2.50.

QUAIN (RICHARD). A Dictionary of Medicine, including General Pathology, General Therapeutics, Hygiene, and the Diseases peculiar to Women and Children. By Various Writers. Edited by Richard Quain, M. D., In one large 8vo volume, with complete Index, and 138 Illustrations. (*Sold only by subscription.*) Half morocco, $8.00.

RANNEY (AMBROSE L.). Applied Anatomy of the Nervous System, being a Study of this Portion of the Human Body from a Standpoint of its General Interest and Practical Utility, designed for Use as a Text-Book and as a Work of Reference. **Second edition, revised and enlarged.** Profusely illustrated. 8vo. Cloth, $5.00; sheep, $6.00.

RANNEY (AMBROSE L.). Lectures on Electricity in Medicine, delivered at the Medical Department of the University of Vermont, Burlington. Numerous Illustrations. 12mo. Cloth, $1.00.

RANNEY (AMBROSE L.). Practical Suggestions respecting the Varieties of Electric Currents and the Uses of Electricity in Medicine, with Hints relating to the Selection and Care of Electrical Apparatus. With Illustrations and 14 Plates. 16mo. Cloth, $1.00.

ROBINSON (A. R.). A Manual of Dermatology. Revised and corrected. 8vo. Cloth, $5.00

ROSCOE-SCHORLEMMER. Treatise on Chemistry.

Vol. 1. Non-Metallic Elements. 8vo. Cloth, $5.00.
Vol. 2. Part I. Metals. 8vo. Cloth, $3.00.
Vol. 2. Part II. Metals. 8vo. Cloth, $3.00.
Vol. 3. Part I. The Chemistry of the Hydrocarbons and their Derivatives. 8vo. Cloth, $5.00.
Vol. 3. Part II. The Chemistry of the Hydrocarbons and their Derivatives. 8vo. Cloth, $5.00.
Vol. 3. Part III. The Chemistry of the Hydrocarbons and their Derivatives. 8vo. Cloth, $3.00.

ROSCOE–SCHORLEMMER. Treatise on Chemistry.
Vol. 3. Part IV. This part includes a description of the Aromatic Compounds containing seven atoms of Carbon. The first portion is concerned with the Toluene Group, then come the Benzyl, Benzoyl, and Hydrobenzil Groups, and lastly the Xylene Group of eight Carbon Compounds. Cloth, $3.00.

ROSENTHAL (I.). General Physiology of Muscles and Nerves. With 75 Woodcuts. 12mo. Cloth, $1.50

SAYRE (LEWIS A.). Practical Manual of the Treatment of Club-Foot. **Fourth edition, enlarged and corrected.** 12mo. Cloth, $1.25.

SAYRE (LEWIS A.). Lectures on Orthopedic Surgery and Diseases of the Joints, delivered at Bellevue Hospital Medical College. **New edition,** illustrated with 324 Engravings on Wood. 8vo. Cloth, $5.00; sheep, $6.00.

SCHROEDER (KARL). A Manual of Midwifery, including the Pathology of Pregnancy and the Puerperal State. Translated into English from the third German edition, by Charles H. Carter, M. D. With 26 Engravings on Wood. 8vo. Cloth, $3.50; sheep, $4.50.

SCHULTZE (B. S.). The Pathology and Treatment of Displacements of the Uterus. Translated from the German by Jameson J. Macan, M. A., etc; and edited by Arthur V. Macan, M. B., etc. With One Hundred and Twenty Illustrations. 8vo. Cloth, $3.50.

SHOEMAKER (JOHN V.). A Text-Book of Diseases of the Skin. Six Chromo-Lithographs and numerous Engravings. 8vo. Cloth, $5.00; sheep, $6.00.

SIMPSON (JAMES Y.). Selected Works: Anæsthesia, Diseases of Women. 3 vols., 8vo. Per volume. Cloth, $3.00; sheep, $4.00.

SKENE (ALEXANDER J. C.). A Text-Book on the Diseases of Women. Illustrated with two hundred and fifty-four Illustrations, of which one hundred and sixty-five are original, and nine chromo-lithographs. (*Sold by subscription only.*) 8vo. Cloth, $6.00; sheep, $7.00.

SMITH (EDWARD). Foods. 12mo. Cloth, $1.75.

SMITH (EDWARD). Health: A Hand-Book for Households and Schools. Illustrated. 12mo. Cloth, $1.00.

STEINER (JOHANNES). Compendium of Children's Diseases: a Hand-Book for Practitioners and Students. Translated from the second German edition, by Lawson Tait. 8vo. Cloth, $3.50; sheep, $4.50.

STEVENS (GEORGE T.) Functional Nervous Diseases: their Causes and their Treatment. Memoir for the Concourse of 1881–1883, Académie Royal de Médecine de Belgique. With a Supplement, on the Anomalies of Refraction and Accommodation of the Eye, and of the Ocular Muscles. Small 8vo. With six Photographic Plates and twelve Illustrations. Cloth, $2.50.

STONE (R. FRENCH). Elements of Modern Medicine, including Principles of Pathology and of Therapeutics, with many Useful Memoranda and Valuable Tables of Reference. Accompanied by Pocket Fever Charts. Designed for the Use of Students and Practitioners of Medicine. In wallet-book form, with pockets on each cover for Memoranda, Temperature Charts, etc. Roan, tuck, $2.50.

STRECKER (ADOLPH). Short Text-Book of Organic Chemistry. By Dr. Johannes Wislicenus. Translated and edited, with Extensive Additions, by W. H. Hodgkinson and A. J. Greenaway. 8vo. Cloth, $5.00.

STRÜMPELL (ADOLPH). A Text-Book of Medicine, for Students and Practitioners. With 111 Illustrations. 8vo. Cloth, $6.00; sheep, $7.00.

SWANZY (HENRY R.). A Hand-Book of the Diseases of the Eye, and their Treatment. With 122 Illustrations, and Holmgren's Tests for Color-Blindness. Crown 8vo. Cloth, $3.00.

TRACY (ROGER S.). The Essentials of Anatomy, Physiology, and Hygiene. 12mo. Cloth, $1.25.

TRACY (ROGER S.). Hand-Book of Sanitary Information for Householders. Containing Facts and Suggestions about Ventilation, Drainage, Care of Contagious Diseases, Disinfection, Food, and Water. With Appendices on Disinfectants and Plumbers' Materials. 16mo. Cloth, 50 cents.

TRANSACTIONS OF THE NEW YORK STATE MEDICAL ASSOCIATION, VOL. I. Being the Proceedings of the First Annual Meeting of the New York State Medical Association, held in New York, November 18, 19, and 20, 1884. Small 8vo. Cloth, $5.00.

TYNDALL (JOHN). Essays on the Floating Matter of the Air, in Relation to Putrefaction and Infection. 12mo. Cloth, $1.50.

ULTZMANN (ROBERT). Pyuria, or Pus in the Urine, and its Treatment. Translated by permission, by Dr. Walter B. Platt. 12mo. Cloth, $1.00.

VAN BUREN (W. H.). Lectures upon Diseases of the Rectum, and the Surgery of the Lower Bowel, delivered at Bellevue Hospital Medical College. **Second edition, revised and enlarged.** 8vo. Cloth, $3.00; sheep, $4.00.

VAN BUREN (W. H.). Lectures on the Principles and Practice of Surgery. Delivered at Bellevue Hospital Medical College. Edited by Lewis A. Stimson, M. D. 8vo. Cloth, $4.00; sheep, $5.00.

VOGEL (A.). A Practical Treatise on the Diseases of Children. Translated and edited by H. Raphael, M. D. **Third American from the eighth German edition, revised and enlarged.** Illustrated by six Lithographic Plates. 8vo. Cloth, $4.50; sheep, $5.50.

VON ZEISSL (HERMANN). Outlines of the Pathology and Treatment of Syphilis and Allied Venereal Diseases. **Second edition,** revised by Maximilian von Zeissl. Authorized edition. Translated, with Notes, by H. Raphael, M. D. 8vo. Cloth, $4.00; sheep, $5.00.

WAGNER (RUDOLF). Hand-Book of Chemical Technology. Translated and edited from the eighth German edition, with extensive Additions, by William Crookes. With 336 Illustrations. 8vo. Cloth, $5.00.

WALTON (GEORGE E.). Mineral Springs of the United States and Canadas. Containing the latest Analyses, with full Description of Localities, Routes, etc. **Second edition, revised and enlarged.** 12mo. Cloth, $2.00.

WEBBER (S. G.). A Treatise on Nervous Diseases: Their Symptoms and Treatment. A Text-Book for Students and Practitioners. 8vo. Cloth, $3.00.

WEEKS (CLARA S.). A Text-Book of Nursing. For the Use of Training-Schools, Families, and Private Students. 12mo. With 13 Illustrations, Questions for Review and Examination, and Vocabulary of Medical Terms. 12mo. Cloth, $1.75.

WELLS (T. SPENCER). Diseases of the Ovaries. 8vo. Cloth, $4.50.

WYETH (JOHN A.). A Text-Book on Surgery: General, Operative, and Mechanical. Profusely illustrated. (*Sold by subscription only.*) 8vo. Buckram, uncut edges, $7.00; sheep, $8.00; half morocco, $8.50.

WYLIE (WILLIAM G.). Hospitals: Their History, Organization, and Construction. 8vo. Cloth, $2.50.

Cupri Sulph grs XLV
Sodium Et K. Tart ʒ IV
Caustic Soda Sol ℥ ISS

{Haines' Test for Sugar}

Coper Sulpate (Squibbs) - - grs XXX
Water - - - - - - - - - - ʒ SS
Make Solution and add
Pure Glycerine - - - - ʒ SS
Mix thoroughly & add
Liquor Potassae - ...... ʒ V

15
100
486) 1500 (3
144
1000

Cupri Sulph 34

Sodium Pot. Tart - 173

Caustic Soda Sol 500

3 ½

45 gr

17
15
85
17
255

Cup Sulph 4 ʒ

Roschelle 12 ʒ

1000
15 50
6 15
480) 15000 (31
1440
600

Aqua O ij

Cupri Sulph ʒ i

Roshelle ʒ vi

Caustic Sol ʒ xv

34
15
170
34
510

173
15
865
173
2595

15
2610
1 5

[illegible]

LANE MEDICAL LIBRARY

This book should be returned on or before
the date last stamped below.

AUG 21 1977

J53 Hofmann, K.B. 83963
H69b Analysis of the ur
1889

NAME